MESSMATES

A BOOK OF STRANGE COMPANIONSHIPS

EDWARD STEP, F.L.S.

Charles Hose

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MESSMATES

PLATE I

CROCODILE AND EGYPTIAN PLOVER.

Frontispiece

This association was well known in ancient days, for it was recorded by Herodotus.

By T. Carreras.

MESSMATES

A BOOK OF STRANGE COMPANIONSHIPS IN NATURE

BY

EDWARD STEP, F.L.S.

AUTHOR OF "WAYSIDE AND WOODLAND BLOSSOMS," "THE ROMANCE OF WILD FLOWERS," ETC.

With 55 Illustrations on art paper
from Original Photographs and Drawings

LONDON
HUTCHINSON & CO.
PATERNOSTER ROW

[1913]

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INTRODUCTION

The time is still not far behind us when every case of constant association of one animal with another was set down as parasitism. We are so apt to jump to conclusions, to take the superficial view, and to condemn on merely circumstantial evidence, that we often miss the true explanation. Fortunately, there are many present-day observers of nature who are inclined to test the deductions of their predecessors by a re-examination of the recorded facts and a search for additional evidence. This has resulted in the modification of many of the older conclusions; and a large number of cases formerly considered as parasitism are now known to be something very different.

In parasitism one creature lives at the expense, and to the detriment, of another species. But there are numerous instances in which two distinct and unrelated creatures are found constantly in close association without any cost or loss to either.

There are other cases of association in which it is tolerably clear that, far from there being any loss to either, both partners derive benefit from the connection. It is clear then that, if the word is to retain its old and well-understood meaning, we must no longer label all these cases indiscriminately as parasitism.

Two other designations have been adopted by naturalists to indicate more exactly those cases of association that are obviously not parasitism—Mutualism and Commensalism. To make clear the significance of these two terms let us apply them to humanity. Two friends in good health, each able to earn his own living, agree for the sake of companionship to live together, but each defraying the costs of his own necessities and luxuries. This is a case of *Mutualism*.

Two other friends also agree to share quarters and have a common table; but one may be infirm and wealthy, whilst the other is strong and comparatively poor. The infirm one offers to pay two-thirds of their common expenses if the other will contribute one-third, plus his protection, cheerful companionship or other valuable help. This is *Commensalism*. The pair are *Messmates*, each contributing to hotch-potch according to his

ability or endowment, each affording what the other lacks, and both, therefore, benefiting from the partnership. There are many degrees of perfection in this arrangement. In some cases the partnership is not permanent, but extends only through certain periods of one partner's life, periods during which he may be more susceptible to the attacks of foes, or less able to repel them. Sometimes one partner receives more from the other than he returns; but so long as the relationship is a mutual one, depending upon friendship and not upon force or fraud, it is entitled to be set down as Commensalism.

Throughout animal life, from almost the lowest to the highest forms, we may meet with numerous examples of such partnerships, some of them of creatures apparently so ill-assorted that, but for the repeated observations of reliable witnesses, it would appear more reasonable to regard the alliance as due to force rather than to choice. But these arrangements are not confined to the animal kingdom, for the lowly plants known as Lichens are compound organisms due to a Fungus and an Alga living together symbiotically. Perhaps even more wonderful are the numerous partnerships that have been entered into between animals and

plants. So remarkable are these that some persons find it easier to believe that they are purely fortuitous rather than that they are due to any actual co-operation between organisms which they consider to be separated by an unbridgable gulf. But fortuitous is scarcely the word for associations which are continuous generation after generation. The more striking and interesting of these will be described in the following pages.

I

BEGINNINGS

I

BEGINNINGS

ALTHOUGH it is only within the life of the present generation that the true nature of the associations between creatures (both animal and vegetable) of different structure and habit has begun to be discovered, that is not because the association itself is a new development in their economy. Orthodoxy, whether in science, politics, history, or theology, often blinds us to the truth, the acceptance of dogma doing away with the craving for research. But that it is no new manifestation, like the somewhat similar co-operation and profit-sharing of our own race, may be presumed from the fact that it has been adopted in some of the most primitive types of animals and plants. It is a fair inference that, as these low organisms have retained their primitive structure, they have only done so by maintaining their primitive habits. On this assumption, it will probably help to a fuller realization of the higher developments of partner-

ships if we glance at the beginnings of it among the simpler organisms.

The lowest forms of life known to us are microscopic specks of jelly (protoplasm), so simple in their organization—without anything in the shape of limbs or internal organs—that many of them are variously claimed by botanists as plants and by zoologists as animals. It would be foreign to our purpose to discuss that vexed question here, though, without attempting to decide it, we may for the present consider certain forms with which we have to deal as being plants of a low grade. These are the organisms known as *Zooxanthella* and *Zoochlorella*. They have the plant's faculty of absorbing salts from the water and combining it with carbon from the atmosphere and turning the mixture into starch, upon which animals can feed. The plant contains a substance known as *chlorophyll*, which enables it, in the presence of sunlight, to break up carbon-dioxide (" carbonic-acid gas ") into its chemical elements, retaining the carbon and setting free the oxygen. For many years a number of the lower forms of animal life were known to have green or yellow-brown bodies embedded in their flesh, and these were naturally considered to be a part of the animal organism ;

but more recent researches have proved these to be foreign bodies—let us say single-celled plants—that have by some means established themselves there and are living symbiotically with their host.

Let me make a slight digression to explain in parenthesis that the term *symbiosis* is employed here to distinguish that class of partnership which exists on a physiological basis. The union is so complete that the nutrition of each of the partners depends entirely, or almost entirely, upon its maintenance.

Zoochlorella is a minute green cell, so small that an individual plant is invisible to the unassisted eye. The aid of the microscope is needed to make out its form. It abounds in the sarcode-flesh of such primitive animals as *Heliozoa*, *Paramœcium*, *Stentor* (the trumpet animalcule), and *Ophridium*. The Freshwater Sponge (*Ephydatia fluviatilis*), which encrusts submerged or floating timber in our rivers, lakes and canals, such as lock-gates, barges or floating logs, often contains it in great numbers. It may not commonly be known that this sponge, remarkably differing from its relatives in its choice of freshwater, is a true sponge whose growth is often so luxuriant that it forms masses weighing many pounds. If it is growing where it gets little light its tint is buff or

flesh-colour; but where it is well exposed to actinic rays it is green. Lankester showed long ago that this green colour was due to the presence of chlorophyll in its tissues, and that the chlorophyll corpuscles were similar to those in the cells of green plants. More recently Gamble and Keeble have shown that the cells containing them are really one-celled plants—Zoochlorella or Zooxanthella.

Of our three well-known species of Freshwater Hydra, one is known as *Hydra viridis* because of its bright green colour. It is a small creature, only about a third of an inch in length, which is found by the industrious seeker attached to water weeds. It can contract itself into a little dab of green jelly or extend itself into a long hollow tube, with eight long slender tentacles surrounding the mouth, after the manner of the Sea Anemone. Embedded in the flesh of these thread-like tentacles are little cells in which are coiled still finer threads. If some minute aquatic animal, such as a Water Flea, comes in contact with one of these tentacles the threads are shot out from their cells and pierce the shell of the Water Flea, stinging and paralyzing the luckless creature. The tentacle then conveys it to the Hydra's mouth. Now, the colour of the

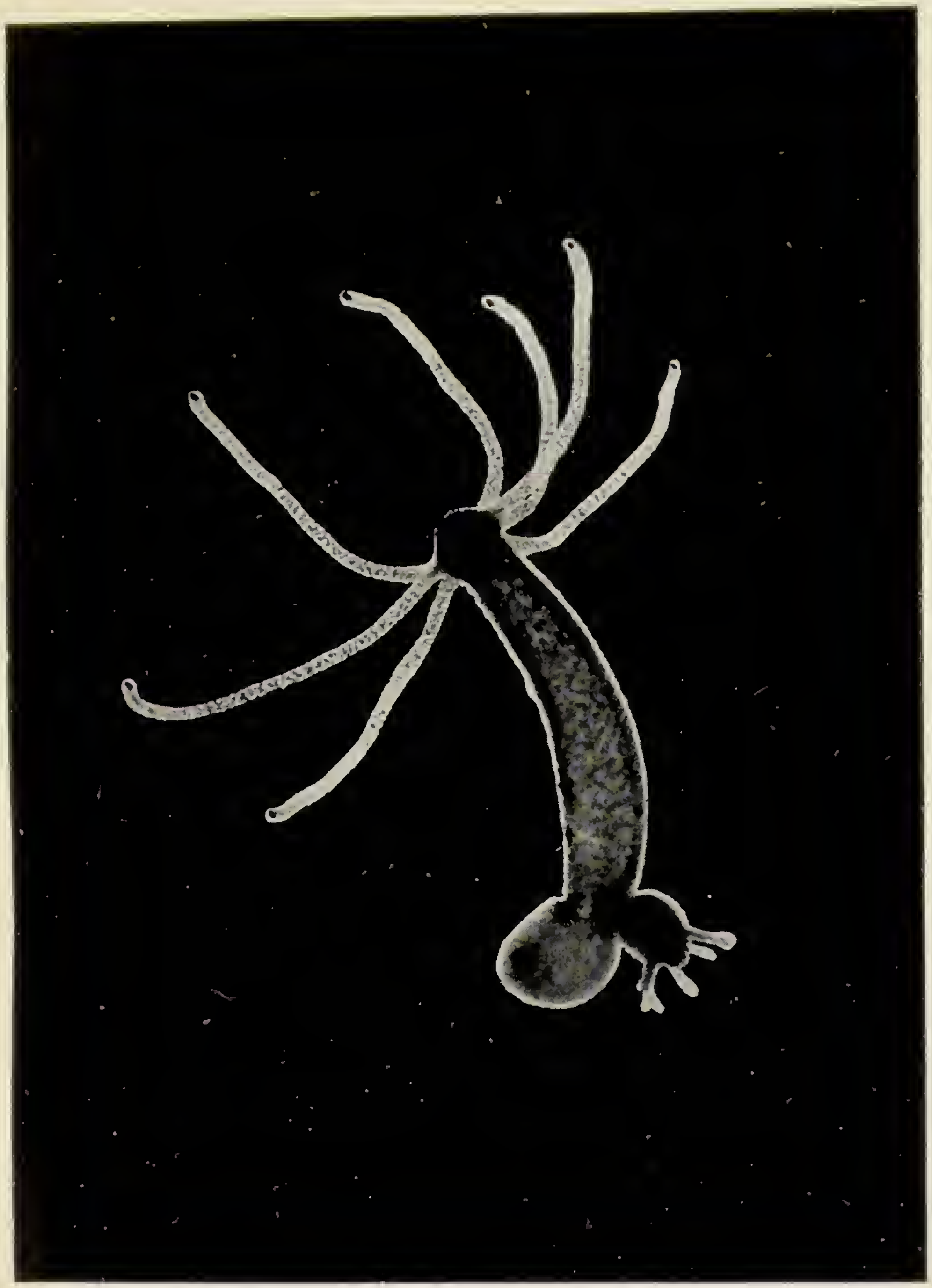

PLATE 2 FRESHWATER HYDRA. Page 6

One species—the Green Hydra—owes its colour to the presence of a host of single-celled plants in its tissues.

Photo by Flatters, Longsight.

Green Hydra is due to the presence of a host of Zoochlorellæ in the outer of the three layers of which its tube-body is composed.

A minute flat worm of a yellow-brown colour, about one-eighth of an inch long, and known as *Convoluta paradoxa*, is common on brown seaweeds on some parts of our coasts. On the shores of Brittany a similar creature, but of green colour —*Convoluta roscoffensis*—may be found in dense patches in sandy pools, looking like masses of green weed. The colour in each case is due to the presence of single-celled plants, brown and green respectively, in their tissues. Haberlandt and Keeble have made exhaustive studies of these creatures, and the results arrived at by the latter especially are a revelation of the importance of these plants to all those low forms of life we have mentioned as harbouring them.

The yellow-brown plants that give their colour to Convoluta are known as Zooxanthella, and are very similar to Zoochlorella except in colour. The green of its chlorophyll is masked by a yellow pigment. Like Zoochlorella it is found in the flesh of many low forms of animal life, such as *Radiolaria*, *Vorticella*, *Millepora*, Sea Anemones and Stony Corals.

The association of these plants with Convoluta is remarkable. *Convoluta roscoffensis* in its early stages hunts for its food, which consists of Diatoms, minute Crustacea (Copepods), etc., but a little later does not trouble to take any food from outside itself, living entirely upon the food manufactured by its plant-partner. Keeble succeeded in isolating eggs of Convoluta from infection by the plant cells, and found that the resulting worms developed only up to a certain point ; then their progress was suspended, and a little later they began to languish. The introduction of the Zoochlorella changed all that ; development was resumed and all went well. We cannot go into the details of Keeble's experiments and investigation, but they show that whilst the plant can live an independent life (though it prefers not to do so) the worm cannot exist without its partner, so long has the species habituated itself to such aid. Convoluta, unlike its related worms, is found to have no means of getting rid of the waste substances which are formed in every animal body as the result of its vital activity. Waste substances in the form of uric acid fill its tissues and speedily bring about its death. Zoochlorella can and does make use of this animal waste, converting it by its own vital chem-

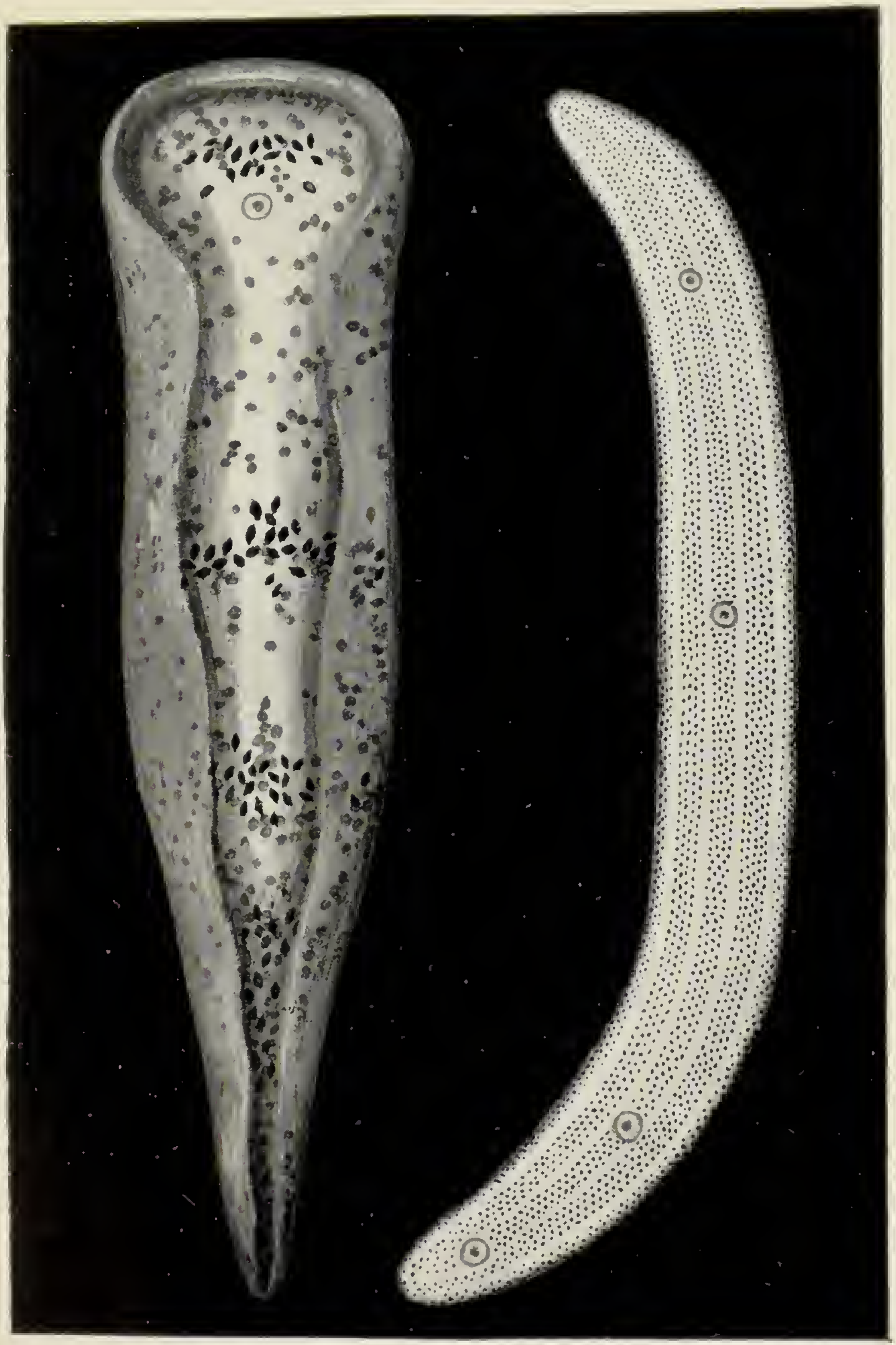

PLATE 3 CONVOLUTAS. Page 8

The left-hand figure is that of Convoluta paradoxa; that to the right is Convoluta roscoffensis.

By T. Carreras.

istry into proteins which enable it to flourish and multiply rapidly. The presence of this great store of nitrogenous waste in the tissues of Convoluta is the consideration which has induced generations of Zoochlorella to establish themselves as commensals of the worm. On the other side of the partnership account, Convoluta gets all its food from the activity of the plant. It is a real-life version of the fable formerly told of the people of Scilly—that they earned a frugal living by taking in each other's washing! There must, of course, be finality in these arrangements. A time comes when the supply of nitrogen gets much reduced by this constant interchange, owing to the fact that Convoluta has grown too lazy to hunt for external supplies and has taken to digesting the plant-cells. That is the beginning of the end, for with a reduction of numbers of the plant less protein is manufactured. More and more plant-cells are sacrificed to make up the deficiency, until at length the animal dies of starvation. Had it been content to act as a working partner all would have been well; but it insisted on taking such high dividends that the capital of the concern was encroached upon more and more, and ruin resulted. This case, therefore, will only stand as a good

example of symbiosis up to a certain stage in its history. Nevertheless, it is one of exceeding interest.

A much more perfect example of such partnerships is afforded by the numerous tribe of Lichens. There was a time—not long ago—when the Lichens were considered as good and distinct a class of plant-life as the Flowering Plants or the Fungi. But in recent years it has been shown that the Lichen is not a single entity but a compound, produced by the association of two plants utterly unlike in their structure, and their mode of life—a Fungus and a Green Plant. All the Fungi agree in this important particular—that, having no chlorophyll, they are utterly unable to break up carbon-dioxide ("carbonic acid gas"), and therefore cannot secure the carbon they must have unless they can appropriate what has already been made by a Green Plant for its own use. Therefore, all Fungi have to live as either saprophytes or parasites. Saprophytes are those that feed upon the decaying remains of animals or plants, in which substances they find the organized material they are unable to manufacture for themselves. Parasites attack the living tree, and by secreting a ferment in its tissues break down its firm structures

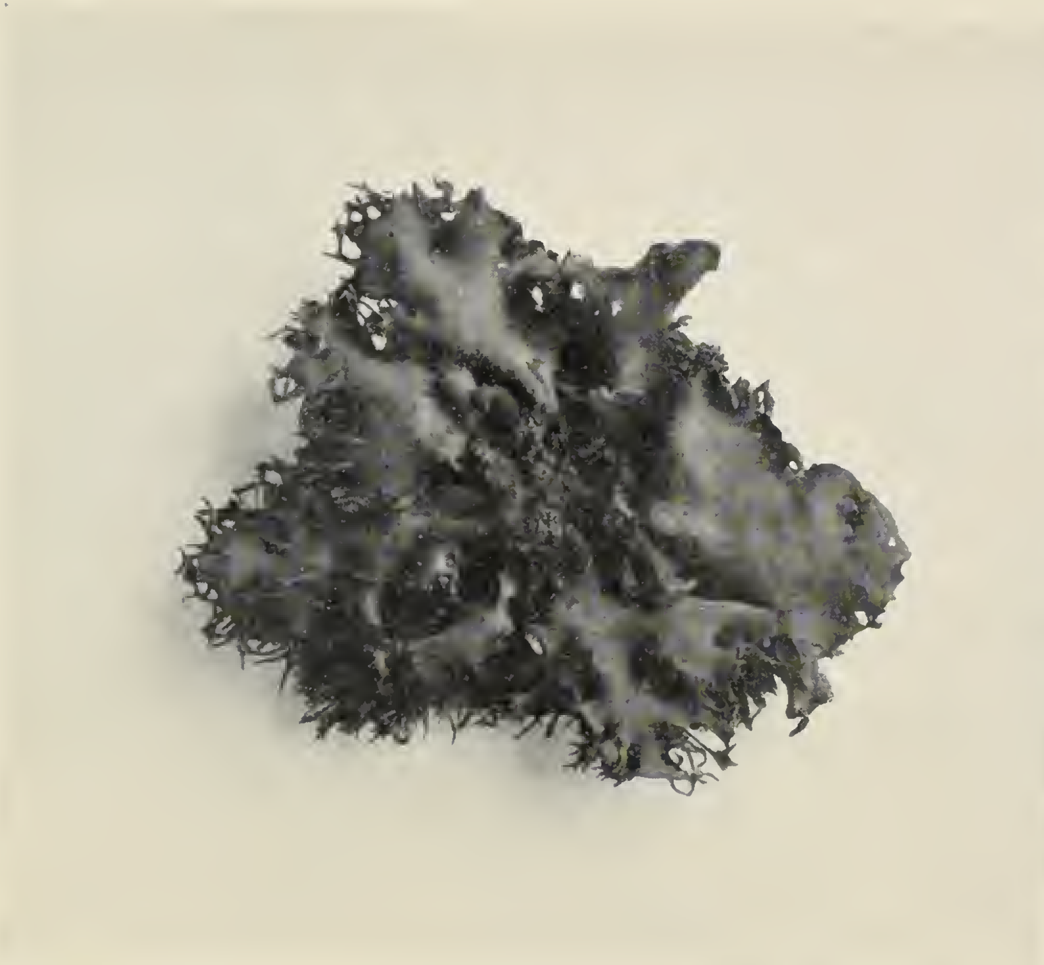

PLATE 4 A LICHEN (*Gyrophora cylindrica*). Page 10

To the right is a magnified section through another species (*Sticta*) showing the Algal cells between the Fungal threads.

Photo by Author.

—though it be solid oak timber—and appropriate its valuable constituents. A single fungus may produce millions of microscopic spores, each capable under favourable conditions of developing ultimately a mushroom or toadstool like that by which it was produced. But unless these invisible spores have the good fortune to be dropped by the air currents that carry them on suitable material, the spore perishes. Probably not one in a million is ever so fortunate; and so the waste of spore production is prodigious.

Now, we can imagine some particularly "cute" fungus in far distant ages reasoning thus: This is deplorable waste. If we could only tame some of these clever green plants and get them to share the results of their skill, how much easier and longer lives we could live. We may further imagine the wily fungus suggesting to a free and independent single-celled Alga—who really stood in no need of his friendship—what a good thing it would be if they joined forces. He by his root-hairs could keep the Alga—whose name was probably Sphærella—supplied with water in which various useful salts were dissolved, and Sphærella could work these up with carbon from the air into palatable food for both. By whatever means it was brought

about, we know that some arrangement was effected ; that it was copied by other strangely assorted couples, and that these unions have lasted for ages, for at the present time there are thousands of distinct forms of Lichens, though it is believed that so far as their green cells are concerned the number of distinct Algæ supplying them is very small.

The fungus-threads combine, as they do in separate existence, to form flat expanses, and between the layers the green algal cells are accommodated. Schwendener, who first made clear this dual nature of the Lichen, erred in his view of the association, which was that the green cells were slaves kept everlastingly at work under the whip of their owner, the fungus. It is really a case of symbiosis, more perfect than that of Convoluta and Zoochlorella, for it does not end in the early death of either partner, but on the contrary it probably adds greatly to the life of both. There must, of course, be partial death to each element in the partnership, but there is a concurrent renewal, so that the compound organism becomes perennial and long-lived. How long their lives are no one knows. The Rev. Hugh Macmillan estimated that certain patches he had ex-

amined in the Scottish Highlands had existed from a date little later than the Glacial Period, which seems a very generous estimate. Prof. Berkeley with more restraint says : " I have watched individuals for twenty-five years, which are now much in the same condition as they were when they first attracted my notice. Plants which endure without injury such extremes of temperature and conditions of the hygrometer, would seem, *a priori*, to be likely to have great powers of longevity."

The fungal partner absorbs water and other material from the rock or bark upon which it is seated, and portions of this material, which may once have formed part of a living organism, it is able to deal with itself, but the non-organized elements it passes on to be dealt with by the green cells. The fungus also, as a result of its vital activity, its feeding and waste, gives off carbon and nitrogenous matters. These are food for the green cells, which turn them again into proteins available for the nutrition of the Fungus. And so the symbiosis is complete and well-balanced.

Similar arrangements in which these green or yellow cells figure in the tissues of other low-life forms might be cited ; but it would be to a large

extent a repetition of what has already been described.

Considered from the utilitarian human standpoint, of far greater importance is the symbiosis established between various species of Bacteria (*Pseudomonas*) and the whole tribe of leguminous plants—Clovers, Peas, Beans, Vetches, etc. Here is an organism of microscopic smallness which has been working to enrich the human race from the earliest days, but only during the life of men still in their prime has it been recognized as something distinct from the plant it favours with its co-operation. The ancients knew that to grow a crop of lupins, beans or tares was more beneficial to agricultural land than the process of fallowing, as will be known to students of Virgil and Pliny. To this day it has been customary in Germany to bring tracts of sterile land into fertility and cultivation by sowing crops of Yellow Lupin (*Lupinus luteus*) and ploughing in the green plants. In France barren sands reclaimed from the sea have been made fertile by planting with Furze (*Ulex*) and Broom (*Sarothamnus scoparius*). Yet, though man knew the advantages of these methods of cultivation, he had no inkling of the why and wherefore of it, because the agriculturist of yester-

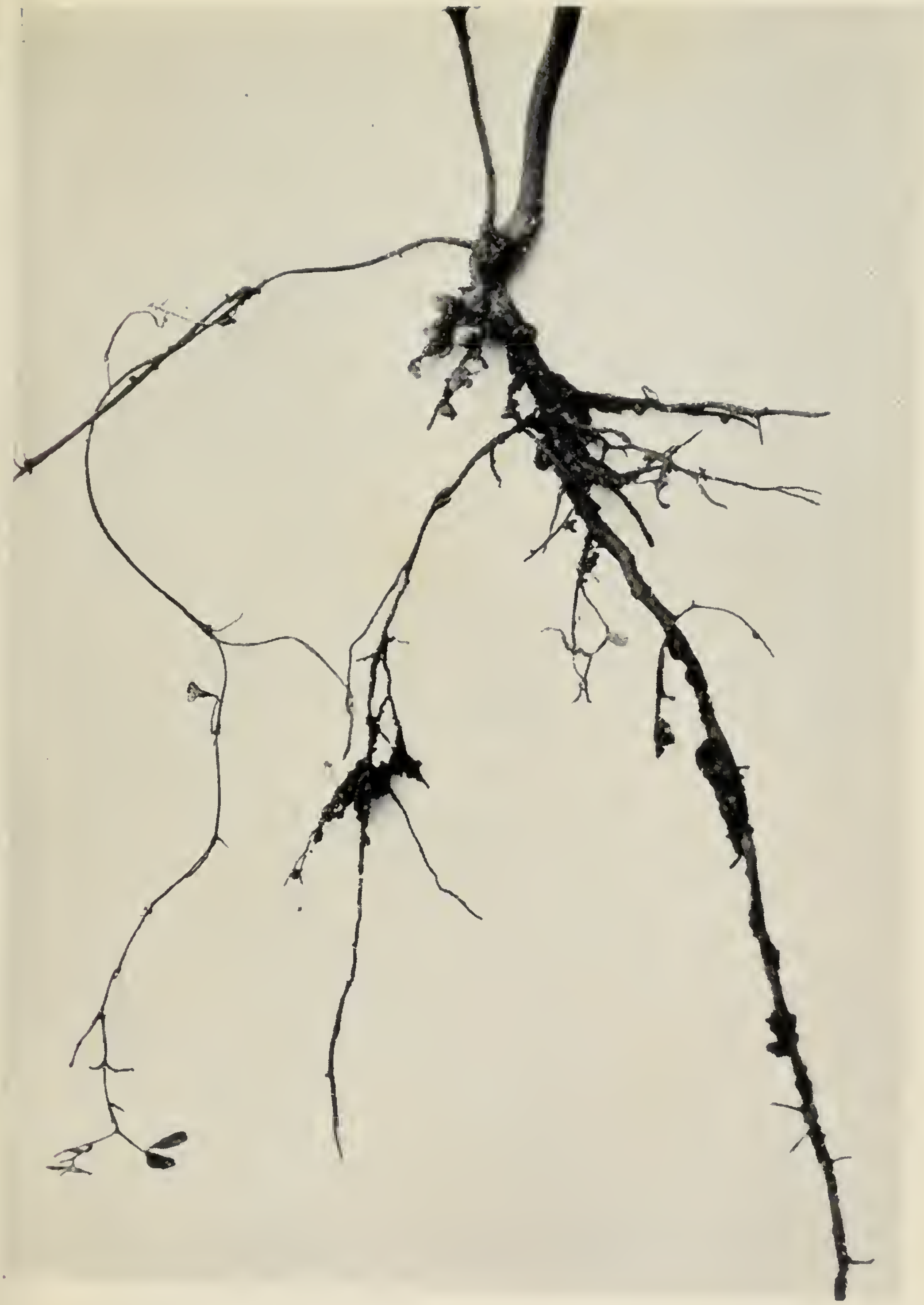

PLATE 5 BACTERIA NODULES ON ROOTS OF CLOVER. Page 14

These will be seen as more or less oval swellings on many parts of the roots.

Photo by Author.

day pooh-poohed science, and to-day is only slowly and by dint of much persuasion being induced to admit the voice of science into his counsels. To feed vast populations with bread and meat he must have plenty of nitrogen in his soil; but there the supplies are rapidly exhausted. The atmosphere consists of nitrogen gas to the extent of nearly four-fifths of the whole, but except the little that falls with rain, in the form of ammonia, there is not much to be found in the soil. Plants, of course, take it in with the air through their stomata, but in its free form as nitrogen gas they cannot utilize it.

But *Pseudomonas* can, and has the power to turn it into such a compound (a nitrate or nitrite) that it can be used as plant-food and thereafter as animal-food. Though, as we have said, these Bacteria are very small—300,000 of them in a line would measure one inch—they are very prolific and short-lived. In a cubic inch of good fertile soil there may be two or three hundred millions of Bacteria of various kinds. The one known as *Pseudomonas* seeks about for the roots of leguminous plants and attaches itself to them, setting up irritation that produces a form of gall, in which it lives and dies. These little nodules, which

any one can find for himself if he digs up the roots of a clover or vetch, gradually become full of bacterial remains, all rich in nitrates which the plant can utilize for its own purposes.

Now, this example of symbiosis must be very ancient. The fact that one or other of these Bacteria attaches itself to any species of Leguminosæ indicates that the habit was set up millions of years ago, when there was only one leguminous plant instead of the seven thousand species now known to exist. It is probable that the Bacteria, by endowing them with great vigour, and coming to their aid in the most unpromising of soils, has largely helped them to form so many distinct species by adapting themselves to all sorts and conditions of life, and so colonizing poor soils that few other plants could exist in. Even microscopic messmates are not to be despised.

The beginnings of this symbiosis between green plants and Bacteria have been found in connection with the Algæ, the division of plants which includes the Seaweeds, the freshwater Confervæ, and the green slimes (Nostoc, etc.), which appear in wet weather on walls, gravel paths, etc. Nostoc is seen as a series of gelatinous bubbles of a blue-green colour, mostly attached to stones that do not

appear to offer much prospect of nutriment. None of the Algæ have roots. They are attached to rocks (in the sea) or to stones, wood, etc. (in streams and on land) by suckers which do not enable them to draw food supplies from their base; instead they absorb their nutriment through all parts of their surface, whether exposed to salt-water, fresh-water or moist air. But like other and higher plants they are unable to make use of free nitrogen without an intermediary, and this they find in various Bacteria which swarm over them and feed upon the jelly-like slime and sugary compounds they pour out on their surfaces. This Nostoc is one of the simpler Algæ, but like the higher forms it needs nitrogen among the other substances (carbon, sulphur, phosphorus, iron, etc.), of which it makes use in building up its cells. Nostoc, simple as it is, is not so insignificant as to be overlooked by the Bacteria. So it is found that it is attended by a Bacterium known as *Azotobacter*, which has the power of turning the free nitrogen gas into a nitrate and giving some of it to the Nostoc in exchange for some of the latter's carbon compounds. The Algæ are regarded as the stock from which all the higher plants have sprung; it is probable, therefore, that in this commensal

alliance between Nostoc and Azotobacter we may see the beginning of processes that have been of the greatest importance to animal (including human) life.

One other example of symbiosis between Fungus and Green-plant must be noticed, though at present comparatively little is known about it. It is a common experience when digging in soil fairly rich in humus, to come across patches of the whitish fine threads, more or less compacted in a thin felt, such as we are familiar with in mushroom beds. Much of this is doubtless the mycelium from which in autumn a crop of Toadstools will be sent up above ground; but some patches do not appear to produce anything of the sort, but continue in a purely vegetative condition. Often it will be found enveloping the roots of timber trees and some others. Frank has stated that certain trees depend entirely upon this mycelium—to which he has given the name *Mycorhiza*—for their power of drawing nutriment from the soil. It first appears upon their roots when the trees are as yet but seedlings, and spreads to new roots as they grow. By means of the ferments with which Fungi attack vegetable tissues, this Mycorhiza is believed to break up undecomposed vegetable

remains and bring them to a condition in which the tree-roots can utilize them. In addition, it enables the roots to take up water and the mineral constituents of the soil, to be elaborated into new substances by the leaves. The association is certainly an ancient one, for fossil Mycorhiza have been found attached to the roots of fossil plants in the Coal strata.

II

MUTUALISTS

II

MUTUALISTS

It must be confessed that in many cases of association we know so little of the basis upon which they are founded that it is not an easy task to classify them. So far we have dealt with those animals who not only meet at meal-times but occupy the same or adjoining dormitories. There are other cases in which one party to the compact appears to be passive or may be indifferent; though, of course, he may have a feeling of sincere gratitude for services rendered. Some of these cases look like pure philanthropy of a one-sided nature; but we think that, properly considered, they should be placed under the head of mutualism.

Such an instance is provided by the case of the Crocodile (*Crocodilus niloticus*) and the Egyptian Plover (*Pluvianus ægyptius*) which, in the nature of things, could hardly reside together. The story is one of those ancient ones—it was told by Herodotus—which modern science has had to admit,

perhaps rather reluctantly, to be true. The story was to the effect that this bird—called Trochilus by Herodotus—slips into the crocodile's mouth and picks off the reptile's gums the numerous leeches that fasten upon them; also that the bird warns the reptile of approaching danger by its cries. The bird is frequently seen sitting upon the crocodile's back, and as the latter rests with its jaws widely distended as though waiting for something to fall into them, it is not improbable that so active a bird does pick fragments of food, if not leeches, from the teeth. The alarm note which every bird has would certainly become familiar to the crocodile, who would know that what would startle the bird would in all probability be a matter of interest for him also. The remarkable point is that the reptile should forgo the temptation to close his jaws on his little friend, for birds, as well as all beasts and fishes, are the crocodile's legitimate prey.

Although it is of a similar type of partnership, the alliance between the Buffalo-bird and Buffalo is not nearly so wonderful, because the Buffalo is not carnivorous, and therefore the proximity of the bird cannot tempt the beast to destroy it. The Buffalo, like other large ruminants, is greatly

PLATE 6 BUFFALO AND BUFFALO-BIRDS. Page 24

The bird helps the beast by searching for parasitical grubs that bore beneath his skin.

By T. Carreras.

troubled by the attacks of various flies that lay their eggs in or on its upper parts, and whose grubs feed beneath his skin, producing great swellings and sores. The Buffalo-bird (*Buphaga erythrorhyncha*) in Abyssinia alights on the Buffalo's back and, with its beak for lancet, opens these tumours and extracts the cause of the trouble, which it appropriates for its own food. It is said that solitary beasts are alarmed by the attentions of this bird and flee from it in terror, but that animals in herds, whether buffaloes, oxen or camels, to which it chiefly restricts its attentions, manifest neither alarm nor surprise, not even when he has to perform surgical operations upon them. He does not confine himself to this class of work; indeed most of his ministrations are of a preventive rather than a curative nature, for he catches and destroys the flies before they can accomplish their egg-laying.

A similar office is performed by the Cow-bird (*Molothrus pecoris*) in North America—not in the direction of extracting grubs from beneath the skin of the oxen, but in ridding them of ticks and other parasites. Our own Starling (*Sturnus vulgaris*) is a pretty constant attendant upon flocks of sheep, which it relieves of its pests by searching

for ticks beneath the thick fleece and by chasing and catching flies.

In these cases, it will be seen, the companionship is not continuous but intermittent. The parties do not reside under the same roof, and one only provides a hunting-ground for the other; but though only one actively confers benefit upon the other, the arrangement is mutually advantageous. Somewhat similar relationships are found in which fishes play a part; but they seem to us to be still further removed from true commensalism. They are mentioned here mainly because they are classic, and with a view to giving a clear idea of what the relationship really is. One of these is the case of the Pilot Fish (*Naucrates ductor*) which occasionally appears off our south-western coasts in the company of Blue Sharks (*Carcharias glauca*). The story goes that it acts as a pilot to the Shark, leading it to the schools of pilchards, mackerel, and other fish, and in return securing protection from large carnivorous fishes that would attack it but for the presence of the more terrible Shark. To make this story good, one has to assume that the Shark is less gifted in the matter of food-finding than the Pilot; but whatever may be the true explanation of the circumstance it appears to be quite true that these

PLATE 7 SHARK AND PILOT-FISH. Page 26

The Pilot-fish is fond of accompanying ships, sharks, and other large bodies through the deep.

By T. Carreras

two fishes do associate. The Pilot seems to have a liking for rapidly moving bodies that are much larger than itself, and for this reason it frequently accompanies ships on long voyages. It is really from this habit that it got its name of Pilot from the sailor-men, who are quick to notice facts of this kind. But really it is one of the things that have been taken note of from very early times, as we find from the references of Ælian, Ovid, Pliny and Oppian among ancient writers. Ovid refers to the Pilot Fish as the—

> "Companion of the swift-winged ship,
> Its constant friend o'er all the foaming deep."

The prevailing idea was that the Pilot objected to shallow water and the proximity of land, and that it left the ship in the event of its approaching either, and therefore fulfilled the proper functions of a pilot in showing the safe course for the navigator. Oppian has embodied the contemporary belief in these lines :

> "He the deep seas prefers to noisy straits,
> Who for the distant ship impatient waits,
> The friendly Pilot Fish, who gladly views
> The well-rigged bark, and every sail pursues.
> Round it the wanton shoals in order move,
> And, frisking, gaze on him who steers above :

> Eager press on, nor will be left behind,
> Though the full sails swell bloated with the wind.
> Thus they, while no approaching shores displease,
> Swim with the ship tumultuous o'er the seas;
> But when they, conscious, scent the coming shore,
> Averse, they court the sailor's look no more;
> Avoid the nearer land, and hie again
> With equal haste to the unbounded main.
> Pilots observe the sign, and know the coast
> Draws nigh when they perceive their comrades lost."

They have been known to follow a vessel all the way from Alexandria, right through the Mediterranean and the Bay of Biscay to Cornish waters; but they object to the Bristol Channel and the English Channel east of Plymouth. Of the same character appears to have been the friendliness of an individual porpoise who for years accompanied ships through the Pelorus Strait between the north and south islands of New Zealand, and was known in consequence as "Pelorus Jack." Many animals have from time to time had Acts of Parliament passed for their protection *as a class*, but "Pelorus Jack" had the unique distinction of having such a legislative enactment passed for his *individual* safety—and he deserved it.

But Pilot Fishes are not the only constant companions of the sharks in deep water. The Remora

or Sucking Fish (*Echeneis remora*) attaches himself to the shark by means of his remarkable sucker, mainly, it may be presumed, for the purpose of getting free carriage and to obtain scraps from the shark's feasts. The advantage to the shark, if any, is not apparent. It is quite a common thing to see these three fishes in constant association. The shark if not well disposed towards his attendants might have difficulty in ridding himself of the Sucker, but it would be an easy task to dispose of the Pilot. The probability is that some service is rendered by it which has, so far, escaped the notice of naturalists. Moseley tells us that during the famous voyage of the *Challenger*, "The sharks were often seen attended by one or more Pilot Fish, as well as bearing the 'Suckers' attached to them. I often watched with astonishment from the deck this curious association of three so widely different fish, as it glided round the ship like a single compound organism." He expresses the opinion that the reason for the Pilot Fish following the ship is that it mistakes it for a large shark, and swims for days just before the bows, which it takes for the shark's snout. "After a time the fish becomes wiser and departs, no doubt thinking it has got hold of a very stupid shark, and hungrily

wondering why its large companion does not seize some food and drop it some morsels. The 'Suckers' often make the same mistake, and cling to a ship for days when they have lost their shark. I fancy that porpoises and whales, when they accompany a ship for several days, think they are attending a large whale."

Less explanation can be given of the behaviour of a fish known as *Polyprion cernuum*, which accompanies floating timber upon which, as usual, those cheap travellers the Ship Barnacles (*Lepas anatifera*) have attached themselves. As the Barnacles subsist upon the microscopical life that abounds in the sea, there is here no probability of the fish attending in the hope of getting crumbs from the upper table. Neither can it be from the protection afforded by its companion; for the Barnacle has no weapons of offence, and its only defence is to close the valves of its compound shell. On the other hand, there does not appear to be any advantage to the fish in keeping close to such a messmate as the Barnacle. We must leave it for time to provide an explanation; unless we are content to consider it as a case of commensalism of the purest type—that is to say, one in which neither party to it is actuated by the prospect of getting

PLATE 8 FIERASFER AND SEA CUCUMBER. Page 30

The Fierasfer treats the Sea Cucumber as a hiding-place from which he can pounce upon passing prey.

By T. Carreras.

an advantage from it. It may be so, but we think that more accurate observation will some day afford us an explanation more on the lines of mutual advantage.

The case of the Fierasfer and the Sea Cucumber (*Holothuria*) has long been known; but it cannot be considered a case of commensalism. Probably the appropriate term for it would be a case of impudent trespass on the Sea Cucumber's privacy. The case stands thus: the Sea Cucumber, who is a degenerate Sea Urchin—though the eaters of Trepang might not like to hear it so called—is largely hollow. His internal cavity is lined with a beautiful system of blood-vessels known as a respiratory tree, and in order that the blood in these vessels may take up oxygen from the sea-water, it has an opening at the rear of the animal. By the action of its muscles water alternately rushes in and out of this aperture, and a small thin fish, the *Fierasfer acus*, goes in tail first, and with his head just inside the portal watches for any likely prey to pass. Then he rushes out and seizes it. So far as can be ascertained, the Sea Cucumber is no party to this arrangement. Possibly, in marine society he may be the object of much obloquy for his supposed harbouring of this bandit. Another

species of the same family makes use of the shell of the living Pearl Oyster in the Bay of Panama, as lodgings for which he pays no rent by conferring benefit upon the oyster. It is almost a satisfaction to learn that sometimes retribution overtakes him. The oyster manages by some means to stifle the intruder—perhaps by persistently keeping his valves closed until the Fierasfer dies of starvation. However this may be, we know that something of the kind happens, for occasionally the body of a Fierasfer will be found coated with pearl in one of these oysters. There is an example of one so treated in the Shell Gallery of the British Museum of Natural History.

Evil examples get copied even among the lower orders of life. An Australian Pipe-fish (*Syngnathus intestinalis*) has so completely learned the lesson from the Fierasfer that he has taken to the same mode of life in the cavity of a Sea Cucumber.

In the nests of Ants and Termites ("White Ants"), as we shall show in succeeding chapters, there is a considerable variety of guests, some honoured, others treated either with contempt or with active hostility. Some that are merely tolerated by the hosts, but not admitted to friendly relations, may still be regarded as commensals,

for they perform valuable sanitary offices for the community, and are secure from the fatal attentions of birds and other insectivorous animals. The same may be said with regard to one of the larger flies, *Volucella pellucens*, whose larvæ are found in the underground nests of Wasps. One would imagine, seeing that the wasp feeds its helpless grubs upon insect food, that such large and succulent larvæ as those of Volucella could not possibly exist in such a situation. It may be, of course, that they are protected by an unpleasant flavour, or that the numerous spines and bristles with which they are covered is a defence. Probably the latter is the case, for they do not need such protection from anything but the wasps. Even so, if their presence were objected to, the wasp's sting could reach their bodies between the spines. The combs in a wasps' nest are placed horizontally, with the cells open below. In each cell a fat wasp grub hangs head downward. If one takes out an empty comb after the wasps have arrived at the winged state and vacated it, it will be found that each cell at its closed end has a thick layer of black material composed of the grub's excrement and cast skins. It is the office of the Volucella larva to remove this, which serves it as food. This

Volucella grub has the hind body broad, from which it tapers to a very slender head. Gliding over the comb, it inserts its foreparts deep into the cell, which it completely closes with its broad hind body, and thus feeds until the cell is cleaned out and ready for the Queen Wasp to deposit another egg in it. In combs of *Vespa vulgaris* we have examined in autumn, there were large numbers of these Volucella larvæ of various sizes, some being almost full grown, whilst others could have been only a few days old.

Since the foregoing was written we have found that the exact attitude of the Wasps to these larvæ has been ascertained by Fabre. One cannot explore an underground wasps' nest in full working order in the same way that one can investigate the operations of the Ants. The wasp's sting is treated with respect even by naturalists ; and even more so the sting of the Hornet, in whose nest lives a beetle, *Velleius dilatatus*, of which we should like to know more in respect of its relation to its host. But respecting the Wasp and Volucella, Fabre has found out something by means of observation-nests in his study.

In the eighth series of his *Souvenirs Entomologiques*, the veteran French naturalist has told the

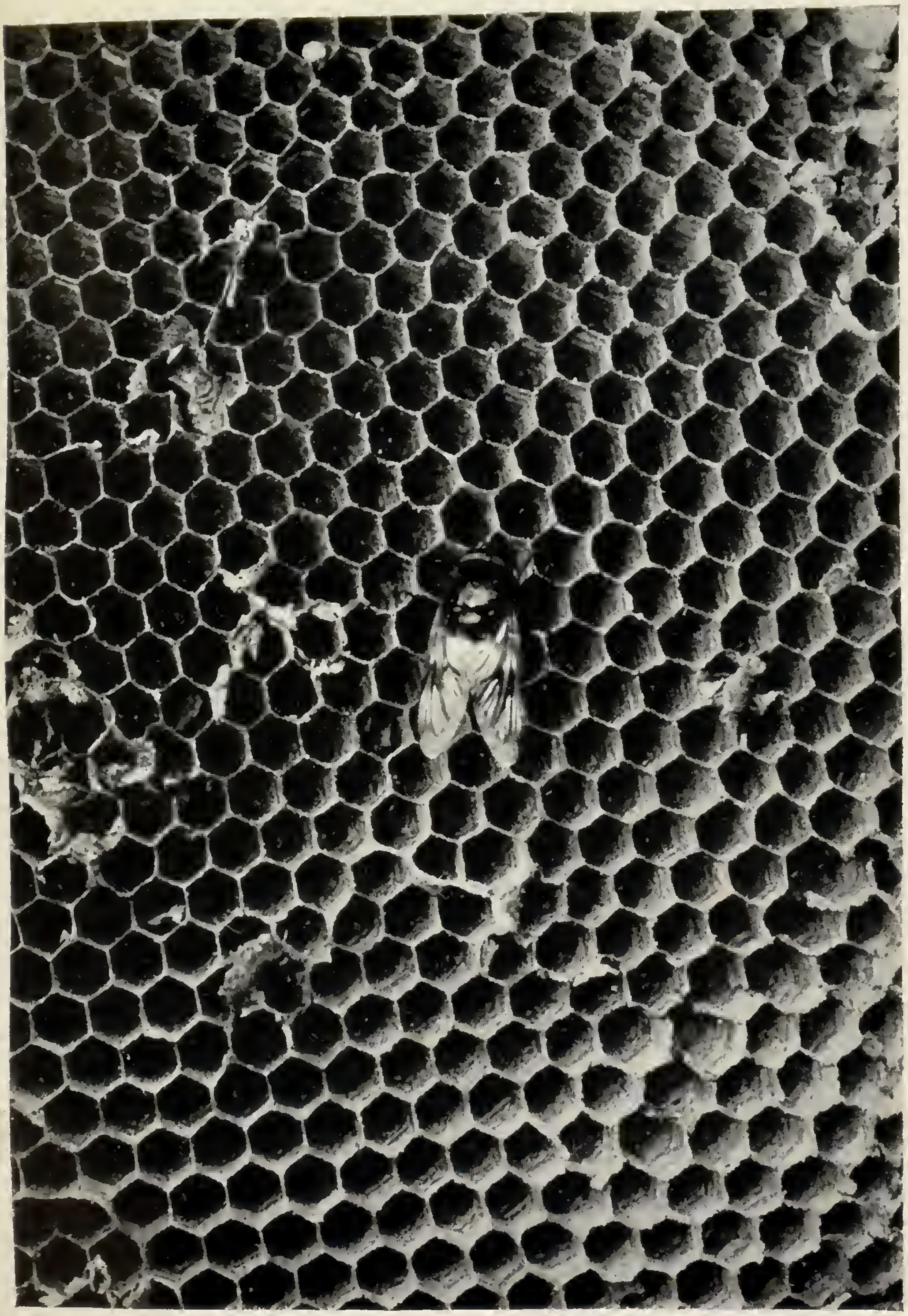

PLATE 9 VOLUCELLA ON WASP COMB. Page 34

The early stages of the Volucella are passed in cleaning out the cells of the wasp comb.

Photo by Author.

story of his experiments with Volucella at some length. He says "Sanitary officer to the wasp city, the Volucella fills a double rôle; it clears the cells of the excrement of the grubs and it rids the nest of its dead. Thus the fly is welcomed peaceably as an auxiliary when it penetrates into the burrow to lay its eggs, and thus in the very heart of the dwelling, where no stranger may wander with impunity, its larva is tolerated, nay, better, is respected." He goes on to tell how he placed larvæ of other insects on his observation-combs, which were promptly seized, run through with stings, and perished immediately. But it was quite another matter with the Volucella larvæ. These came and went at their pleasure, investigating the cells, jostling their occupants, but unmolested by the wasps. For two hours Fabre watched one Volucella grub which had established itself in a cell side by side with a Wasp grub. "The tail of the larva was exposed, spreading out its papillæ, and once or twice the pointed head showed, moving with brusque serpentine motions. The wasps had just been feeding at their patch of honey, and were now distributing their mouthfuls. The work was going on in full daylight at my table in front of the window. Going from one cell to another,

the nurses several times brushed against the intruder, stepping over him. They most certainly saw him. He did not shift his position, except that when trodden upon he drew back, only to reappear the next moment. Some of the passers-by stopped and bent their heads to the mouth of the cell, apparently to ascertain what was going on, and then went off again without in any way bothering themselves as to the state of affairs. One of them went farther; she tried to give a mouthful of honey to the legitimate owner of the cell, but the latter, disturbed by his visitor, had no appetite, and refused. Without the least sign of anxiety on the score of the nursling which she had just observed in such uneasy company, the wasp went off to distribute her mouthfuls elsewhere. In vain I prolonged my observations; there was no sign of any emotion. The Volucella larva was treated as a friend or at least recognized with indifference. No attempt was made to dislodge him, to hustle him, or to put him to flight; nor did he for his part seem to worry himself with these passers-by. He showed by his tranquillity that he felt himself quite at home."

Other careful observations and varied experiments were undertaken by M. Fabre to make quite

Larva. Pupa. Fly.

PLATE 10 — THREE STAGES IN THE LIFE OF VOLUCELLA.

Page 36

Photos by H. Main, F.E.S.

certain that the Wasps fully understood what the Volucella grub was and the nature of its work. Among other things he introduced singly into empty cells a larva of *Saperda scalaris* and a Volucella larva, both of them white and of such size as not to fill up the cell entirely. Their presence was only revealed by the paleness of their backs, which formed stoppers in the mouths of the cells. A superficial examination would prove inconclusive as to the nature of the recluse. The wasps, however, were not deceived; they dragged out the Saperda larva, killed it, and flung it to the refuse heap, but they left the Volucella larva in peace.

Such, says Fabre, is the will of the Wasps'-nest police: every stranger caught to be massacred and cast to the rubbish heap. To escape this vigilance a genuine enemy needs a cunning immobility and a power of dissimulation of a high degree. But the Volucella larva uses no dissimulation, he comes and goes in full view where it seems good to him; in the midst of the Wasps he searches the cells at his convenience. What is it then that makes him thus respected? Strength? Certainly not. He is an unarmed morsel that the wasp could cut in two with one bite of his mandibles. Pierced by the sting, he would be destroyed. He is a recog-

nized guest, to whom in a wasps' nest no one wishes harm. Why? Because he renders them service. Far from being harmful, he works for cleanliness. As an enemy, or merely as an intruder, he would be exterminated; as a worthy helper he is respected.

Moles' nests, too, are good hunting-grounds for the enthusiastic naturalist. Many beetles otherwise rare are to be found therein; but nothing of a definite character has been recorded concerning the relationship of the beetles to their hosts. It may be assumed, however, that the insects are mere hangers on. Among them may be mentioned, *Aleochara spadicea*, *Heterothops nigra*, *Quedius vexans*, *Quedius longicornis*, *Hister marginatus*, *Onthophilus globosus*, *Medon castaneus*, *Oxypoda spectabilis*, *Oxypoda longipes*, *Oxytelus scalpturatus*, *Choleva angustata*, *Choleva nigrita*, etc.

Saville Kent has told of a small spider (*Argyrodes*) in Queensland, that makes no web, but takes up its residence in the snare of the much larger *Nephila fucipes*. A similar, or perhaps the identical, species was also found by him on the webs of *Argiope regalis*, near Brisbane. Adult specimens measure only an eighth of an inch across, and are clothed in a silvery coat that glistens like a dewdrop in

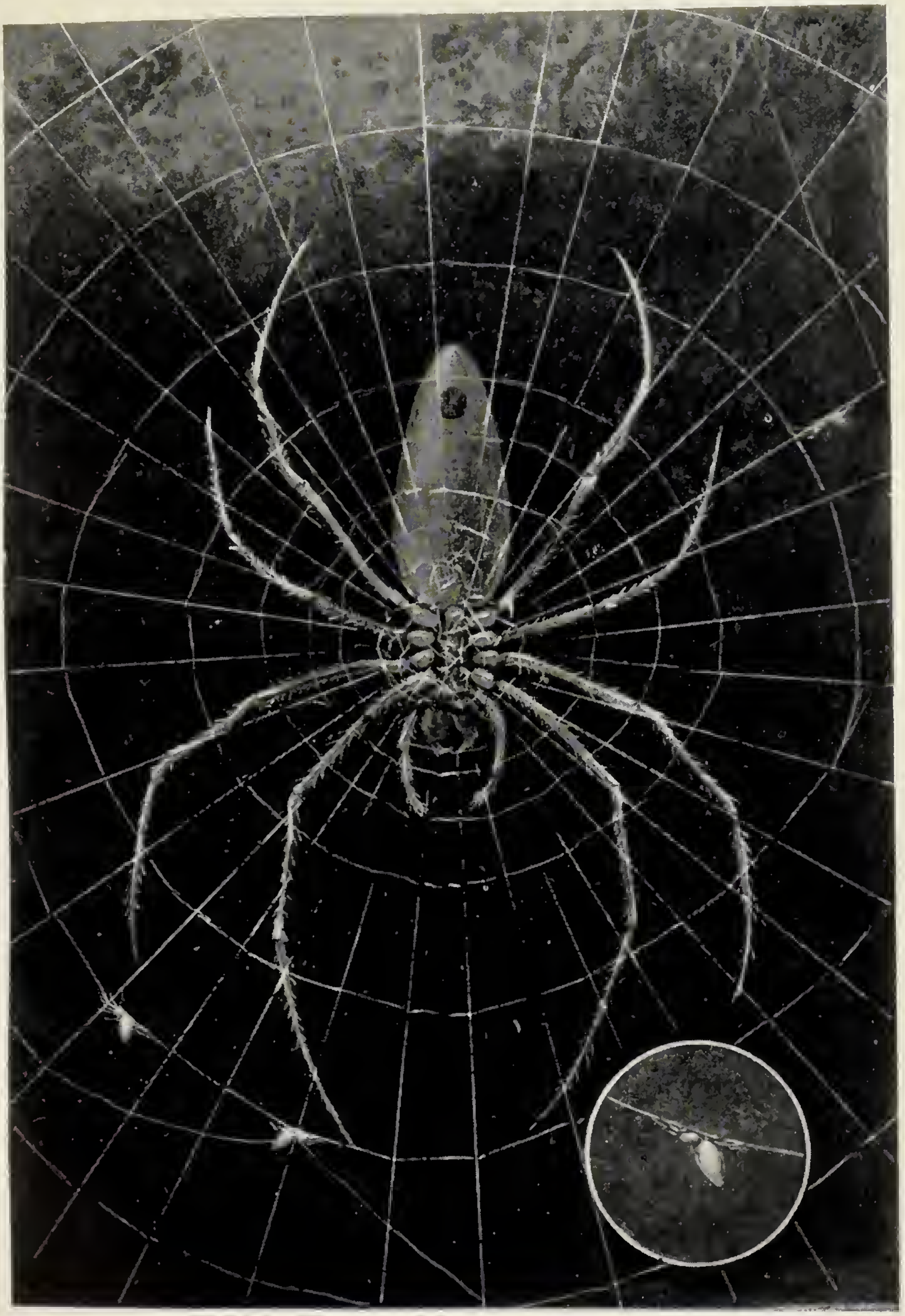

PLATE 11 NEPHILA FUCIPES AND ARGYRODES. Page 38

The large Spider (Nephila) is shown about three-fourths of the natural size. The smaller one (Argyrodes) is shown natural size in the small circle.

By T. Carreras.

the sunshine. It feeds upon the smaller insects that get trapped, but are beneath the notice of the big net-weaver. Other species of *Argyrodes* have similar habits, and it has been suggested as probable that their dewdrop appearance protects them from attack by birds.

III

SPONGES AND THEIR GUESTS

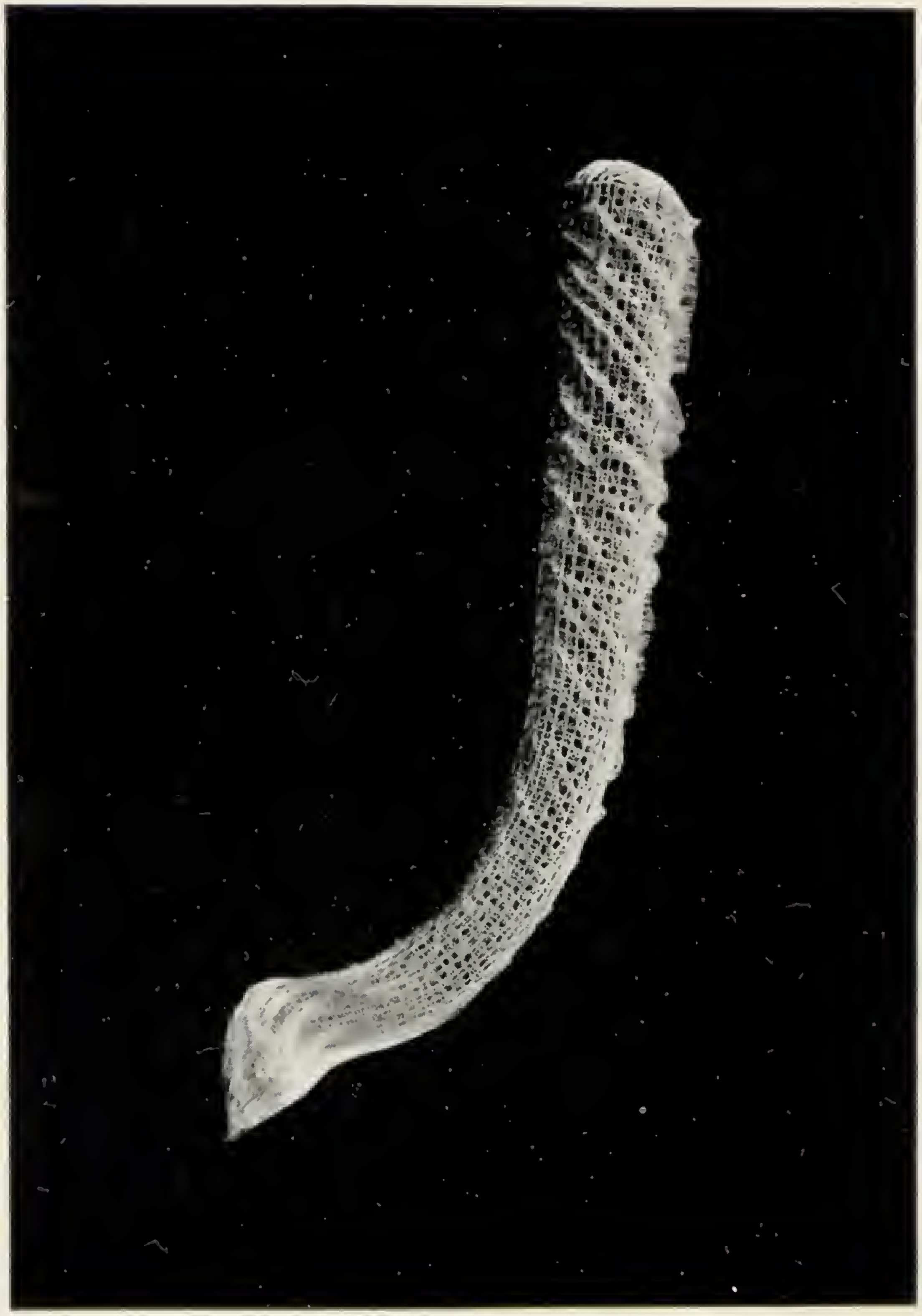

PLATE 12 VENUS' FLOWER-BASKET. Page 43

The beautiful sponge in which a pair of Crustaceans spend their lives.

Photo by W. Plomer Young.

III

SPONGES AND THEIR GUESTS

When we speak of Sponges as hosts we mean, of course, the living Sponge, not the mere skeleton which is an item of commerce and of every-day use. We have already mentioned the fresh-water representative of the family as a commensal of the green-celled Zoochlorella, but other Sponges have effected working arrangements with animals of several different classes. The Glass-rope Sponges and the Venus' Flower-basket have probably awakened more public interest, including admiration, than any other members of their class. When first made known in this country they likewise proved a puzzle to the naturalists. It is one thing to make acquaintance with new forms of life as living things in their proper habitat; it is another matter to have merely a cleaned skeleton without proper data presented to you with a request for full particulars as to its status and mode of life. When the skeleton of the Glass-rope

Sponge (*Hyalonema sieboldi*) was thus introduced to this country it was the subject of much controversy. Originally it was called the Glass-rope, simply because the sponge itself was regarded merely as a base from which the remainder grew. Around the bundle of glass-like threads was found a colony of the Sea-Anemone *Epizoanthus stellaris*, and on this being discovered it was considered to be the architect of the Glass-rope, and the sponge proper was regarded as a parasite upon it. Then the Japanese came to the rescue and explained that the sponge was really the upper and important part of the arrangement, and that the beautiful Glass-rope was merely a mooring rope which descended into the mud and kept the sponge stable. Since those days another species, *Hyalonema thomsoni*, has been found nearer home, H.M.S. *Porcupine* having dredged it from deep water off the Shetlands. Like the original species from Japan, the long glass-like spicules by which it is rooted, are encased by a colony of Epizoanthus. What is the nature of the association it is hard to say. That there is mutual benefit derived from it appears likely from the fact that the anemone is found also on an allied sponge, *Axinella*, from the Adriatic. But this is not the only commensal

PLATE 13 GLASS-ROPE SPONGE AND EPIZOANTHUS. Page 44

The latter will be seen clustered around the "glass-rope."

Photo by W. Plomer Young.

problem that has to be solved in connection with Hyalonema. *Hyalonema masoni* in the Andamans has entangled in its meshes a feeble little lobster-like crustacean, *Richardina spongicola*; and the fact that the latter has not been found except so associated is held by Alcock to indicate that the partnership is a necessary one.

The sponge proper has a central shaft, from which the long spicules of the "glass rope" are produced below, and the body is divided into compartments which have openings at the top. In these compartments dwell a pair of small lobster-like crustaceans (about 1¼ inches long) known to science as *Spongicola venusta*, which means the graceful sponge-dweller. This crustacean is also an inhabitant of the beautiful Venus' Flower-basket (*Euplectella aspergillum*) and of other members of the same genus. Almost every specimen that has been examined contains this guest, and it may fairly be assumed that it is an invariable inmate, but that in some cases it has escaped before the sponge has reached the surface. Such a constant association attracted the notice of the Spaniards at Manilla, and they were firmly of opinion that the flower-basket was a nest woven by the crustacean for its own comfort. They pointed to the fact that

apart from the length of the tube, which would be very difficult for the little " lobster " to climb, the top was closed and there was no opening through which it could enter. Therefore it must weave the nest around itself. The Japanese had also been struck by the constant occurrence of a pair of crustaceans in the nest, and they adopted Venus' Flower-basket as an emblematic decoration for use at marriage festivals, and called it by a name which signified " Together unto old age and in the same grave," or, as another version runs, " Lobsters in the same cell "—and those conversant with English regard the last word as a pun!

But the " little lobster," *Spongicola*, is not the only crustacean that makes a habit of taking up its lodgings in Venus' Flower-basket. There is another species allied to our terrestrial wood-lice, of which there are many marine species, chiefly noted for their attacks upon fish, living and dead, whose bones they clean, so voracious is their appetite. The one that has taken to the life of a hermit in Venus' cell is named *Æga spongophila*, and it is about the same size as *Spongicola*. It has been suggested, with every probability of accuracy, that the Æga finds plenty of victims in the numerous small creatures that are drawn into the baskets by

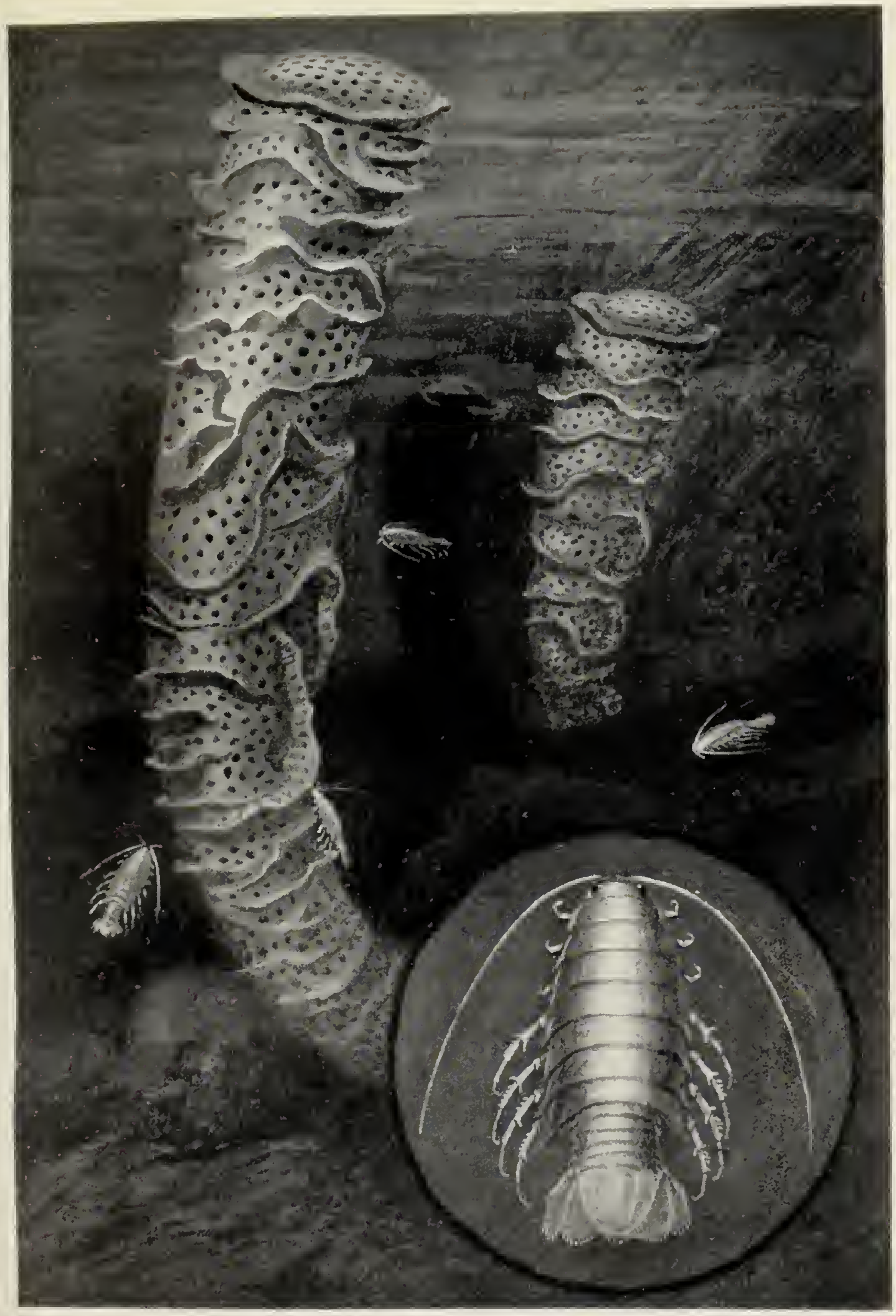

PLATE 14 VENUS' FLOWER-BASKET AND SPONGICOLA VENUSTA. Page 46

Here the Sponge is shown alive. The inset is a life-size figure of the Crustacean.

By T. Carreras.

the currents every living sponge sets up, to say nothing of those that are tempted by natural inquisitiveness to explore the interior. The same suggestion may apply with equal force to the case of *Spongicola*; and it may be assumed that *Aspergillum* on the one hand derives benefit from their presence by having its house kept clean, and that the crustaceans on the other hand are assured of sufficient food without running any of the risks that are the lot of all crustaceans in the open sea.

Another beautiful sponge from the Philippines is *Meyerina claviformis*, and this also has a crustacean messmate—*Cirolana multidigitata*, belonging to the same group as *Æga*.

The Venus' Flower-basket has sometimes in addition a white species of the sea-worm that is known on our shores as the Sea-mouse (*Aphrodita*) and a small Scallop (*Pecten*). It is quite in accordance with the fitness of things that an Aphrodite should take up quarters in a sponge dedicated to Venus.

Another of the beautiful Euplectella family of sponges comes from Japan, and is known as *Walteria leuckarti*. It is nearly three feet in height and consists of a thick walled tube with a solid base. On the outside a large number of branches are

given off at right angles, and these branches are invariably inhabited by a hydroid polyp, *Stephanoscyphus mirabilis* in vast numbers. The presence of these lodgers is evident on every specimen. Little dome-shaped swellings appear on every branch and secondary branch, and every swelling contains its Stephanoscyphus. An allied species, *Walteria flemmingi* is likewise accompanied by the same hydroid. The glass-sponge *Regadrella phœnix* has for messmate the crustacean *Spongicola koehleri.*

The crustaceans we have mentioned in connection with the Glass-rope Sponges are not the only ones that have manifested a liking for the company of sponges. Several of the smaller Hermit Crabs and some of the Spider Crabs exhibit similar tastes, among them Forbes' Hermit (*Eupagurus sculptimanus*) here illustrated. This little crab as soon as he has attained the proper Hermit form protects his soft hind parts by thrusting them into an empty mollusc-shell, and before he has been settled in his house many days the germs of a sponge (*Suberites domuncula*) alight upon it, and developing, in a short time completely hide it from view. This is a distinct advantage for the hermit, for though he adds considerably to his bulk his house will never get too small for him, as is the case with most

PLATE 15 LEUCKART'S GLASS-SPONGE. Page 48

The branches are invariably inhabited by a messmate polyp.

other hermits, who are periodically engaged in the business of house-hunting. The sponge grows forwards and surrounds the crab except in front. As the crab grows he only needs to move forward a little at the time, leaving the mollusc shell far behind imbedded in the sponge. The sponge always respects the rights and the necessities of the crab, and grows in such a manner that the open part is continued in a spiral form as though it were a prolongation of the original shell. Sometimes the Hermit is housed in another sponge, *Ficulina ficus*, but the latter is not constant in its association with crabs. Suberites, on the contrary, never seems to be happy unless he has a companion of this sort, and wherever you may find *Suberites domuncula* you will also find a hermit crab housed in it.

Then there is Dromia, an almost globular crab who looks like a submarine gnome, so quaint and uncrablike is his appearance. He is covered all over with a close pile of short stiff hairs, all except the pink pincers of his first pair of legs. He might quite reasonably pass, and be passed by his enemies, as a weedy stone; but apparently he has reason to fear venturing abroad without some disguise. At any rate, he carries about on his back a sponge

bigger than himself, and so accustomed has the species got to this arrangement that the two hindmost pairs of feet have in effect got shifted to the upper side of the hind part, and their terminal joints become converted into minute pincers, so that they can take a firm grip of the sponge. A foreign species, *Dromia rumphii*, holds a valve of a bivalve shell over its back in a similar fashion. This, by the way, for it does not properly come into our subject; and the Dromias may have to be referred to in a later chapter.

Several of the Spider Crabs deliberately plant cuttings of suitable sponges on their backs with a view to disguise; and most of the Spider Crabs are specially built by nature to assist them in such arrangements. The carapace, or upper shell, is liberally provided with bristles, some of which end in little hooks which securely hold anything so planted. Sponges are intended to attach themselves and grow, but there are other things, such as bits of seaweed, which require changing from time to time, perhaps to harmonize with changed surroundings, such as when the crab leaves a clump of red seaweeds and migrates to a spot where the green weeds are more abundant. Here is a photograph of Gibbs' Spider Crab (*Pisa tribulus*) who has got

PLATE 16 GIBBS' SPIDER CRAB AND SPONGE. Page 50

For disguise this Crab induces a sponge to grow over his shell. *Photo by Author.*

a mass of red sponge actually growing all over her back. Her short limbs (it is a female) do not advance very far beyond the circumference of the sponge, but to make as sure as she can that no crab-loving fish should divine her real class, she has planted small white sponges half-way down her limbs, which have the optical effect of breaking them up so that they do not appear to be connected with the sponge's base. The Scorpion Spider Crabs (*Inachus dorynchus* and *I. dorsettensis*) plant smaller sponges in the valleys of their backs; and some sponges will almost certainly appear in the miscellaneous collection of rubbish among the hooked bristles on the carapace of the Spiny Spider Crab (*Maia squinado*).

Now, what is the secret of this association between animals so widely separated in the scale of organization that, supposing there is a method of communication between animals of the same class, it would seem impossible there could be such means between these? There are three facts which to our mind afford a clue. First, crustaceans of all kinds are a very desirable food—even dull, slow-witted man has found that out, as witness the high prices of lobsters and crabs, to say nothing of prawns and smaller shrimps. Second, all sponges

that we have handled in a living condition have given out a strong, unpleasant odour, probably due to the iodine they contain. Third, a sponge when it has arrived at the end of its brief larval period of liberty and free movement has to settle down for life on one particular spot chosen in infancy. Put these three facts together. The crustacean that has not in the struggle for existence contrived to develop full armour, swimming or running activity or a long reach of a powerful pair of nippers, has small chance of surviving, unless it can disguise itself or strike up an alliance with a creature whose flavour will make any fish's gorge rise. The sponge —or certain sponges that have developed the love of change—is glad to employ a vehicle that will carry it about to fresh feeding-grounds. Here then is sufficient justification for the association. If the enemy detects the crustacean in spite of the disguise, the fact that it must take sponge salad with its meal is probably sufficient to deter it and to cause it to look elsewhere.

IV

SEA-ANEMONES AND CORALS AND THEIR FRIENDS

IV

SEA-ANEMONES AND CORALS AND THEIR FRIENDS

The great division of animal life which includes the Sea-Anemones, the numerous kinds of Corals, and the Hydroid Zoophytes is known as the Cœlenterata. As a class they may be regarded as a very sociable and friendly company, and the fact that as a rule they are armed with dart-pointed threads that have the irritating properties of the stinging nettle makes their friendship a much more desirable thing than their enmity. The sharp-witted crabs have not been at all slow in availing themselves of this friendly disposition; but we propose to exclude the crabs from this chapter and give them one to themselves—or rather to their friendships. Here we shall only mention the fact that certain Cœlenterates have relationships of this character with certain Crustaceans, but shall reserve particulars for the present. Thus, Hydractinia completely covers the mollusc shell adopted as a house by the

Hermit Crab, *Eupagurus pubescens*, and often forms a fringe round the mouth of the Whelk shell inhabited by *Eupagurus bernhardus*. The latter Hermit Crab is also accompanied by the big Anemone falsely called the Parasite; and Prideaux's Hermit is as constantly wrapped round by *Adamsia*. The Hairy-handed Hermit is *always* protected by Epizoanthus, and Anderson's Hermit off the Malabar coast is never found without an Anemone blanket.

One of the Hydroid Polypes, or Hydrozoa, is named *Lar sabellarum* because it was discovered by P. H. Gosse many years ago perched on the tube built by the marine worm *Sabella*. The conjunction was not accidental. Until Gosse so discovered it the Hydroid was absolutely unknown to science, and the fact that it was unknown was probably due to this close association, for if previously seen it must have been mistaken for a part of Sabella or its tube. Since that first discovery Lar has not been found anywhere else. *Lar sabellarum* is one of those zoophytes that at a certain stage in their development free themselves from their cells and go floating off into the sea as exquisite little jelly-fishes.

Another of the same division of the Cœlenterata, *Campaniclava cleodoræ*, has selected for a perch

the glassy shell of one of the molluscs popularly known as Sea Butterflies—*Cleodora cuspidata*, a species that floats in the surface waters of the sea.

One of the Sea Fans (*Gorgonia*) is rather strangely found upon the tubes of *Tubularia parasitica*, one of its own class, which is not a very common feature in symbiosis, the partners as a rule being far removed from each other in the scale of family relationship. A similar case, however, is afforded by another Hydroid which lives on friendly terms with *Ptilosarcus*, one of the Sea Pens, encrusting the edges of its leaves.

The genus *Stylactis* shows a particular weakness for arrangements of this kind. Two of them (*S. spongicola* and *S. abyssicola*) are constantly associated with Horny Corals; and *Stylactis vermicola* has been found only on the back of one of the beautiful worms known as Sea Mice (*Aphrodite*). This particular species of Aphrodite lives at a depth of 2,900 fathoms, so that, as in so many similar associations, it is difficult to keep watch on the partners, and learn the secret of the bond that unites them so faithfully. But the very constancy of such companionship, where parasitism is out of the question, is *prima facie* evidence that it is of mutual benefit. A more singular case is that of *Stylactis*

minoi, which has selected a little fish, the Rock Perch (*Minous inermis*), for its chum, and attaches itself to the scales of his sides. Alcock, who has studied this matter in the Indian Seas, ventures the suggestion that the presence of these polyps in numbers on the fish disguises it by making it resemble the incrusted rocks of its habitat. That both fish and hydroid derive benefit from the association seems clear from the fact that in the Bay of Bengal and the adjacent seas, where the fish lives at depths ranging from 45 to 150 fathoms, you may dredge and net to your heart's content but you will not succeed in bringing up a Rock Perch that is free from the polyp, and you will not find a *Stylactis minoi* that is not attached to the fish. We may not know what considerations brought about this arrangement, but we may be pretty certain that each partner has made himself indispensable to the other.

This division of animal life includes the "Cow Paps" or "Dead-man's Fingers" (*Alcyonium digitatum*) of our own coasts, which has representatives in other parts of the world. In many of the tropical species the superficial canals and spaces have been found to harbour great numbers of the yellow single-celled organisms *Zooxanthella*, already

PLATE 17 ROCK PERCH AND STYLACTIS MINOI. Page 58

Neither of these messmates can be found apart from the other.

By T. Carreras.

referred to in Chapter I. It is thought by some observers that these Algæ, as in the case of *Convoluta*, prepare food for the Alcyoniums and in return derive benefit from the waste nitrogenous material of the animal. Whether such food production is sufficient to support the host is another matter; but it is something to have part of your food provided without cost or effort, and quite sufficient basis upon which to found a symbiotic partnership.

We have briefly alluded to the friendly disposition exhibited by Sea Anemones towards various crabs, which we propose to deal with more fully in a later chapter; but crabs are not the only recipients of their kindly attentions. Prof. Haddon found off the south-west coast of Ireland, the beautiful little Mediterranean Sea-Anemone known as *Gephyra dohrnii*, commensal upon the tubes of a zoophyte, *Tubularia*. Whether the association is a constant one remains to be seen. As the two creatures belong to the same division of animal life, and are largely interested in the same kind of food, it is perhaps a doubtful case; but the fact that they have been found in great numbers thus associated makes it look otherwise. About the same time and place, Haddon was the fortunate finder of another Anemone—this time an entirely unknown

species—which he has called *Chitonactis marioni*; he found it attached to the spines of the Piper Sea Urchin (*Cidaris papillata*). As in the previous case, further observation will be needed to show whether this was a mere accidental or temporary perch made use of by the Anemone, or whether the two dissimilar creatures are commonly found in association.

On the tropical parts of the Australian coast—where the Great Barrier Reef affords splendid hunting-grounds for the naturalist—there are huge specimens of Anemones. One of these is known as *Stoichactis kenti*, and Mr. Saville Kent, after whom it is named, says that it has spheroidal bead-like tentacles which occur among others irregularly mixed in patches of grey, white, lilac and emerald green, the disc being shaded with tints of grey, while the mouth is bordered with bright yellow. Now, in admiring these giant anemones, you will scarcely ever come across a specimen without seeing a fish of the Perch family (*Amphiprion percula*) swimming about among the tentacles. Knowing what we do about these tentacles, how not only have they the power of instantly clasping the fish from all sides and carrying it to the anemone's mouth, but of thrusting out stinging threads that

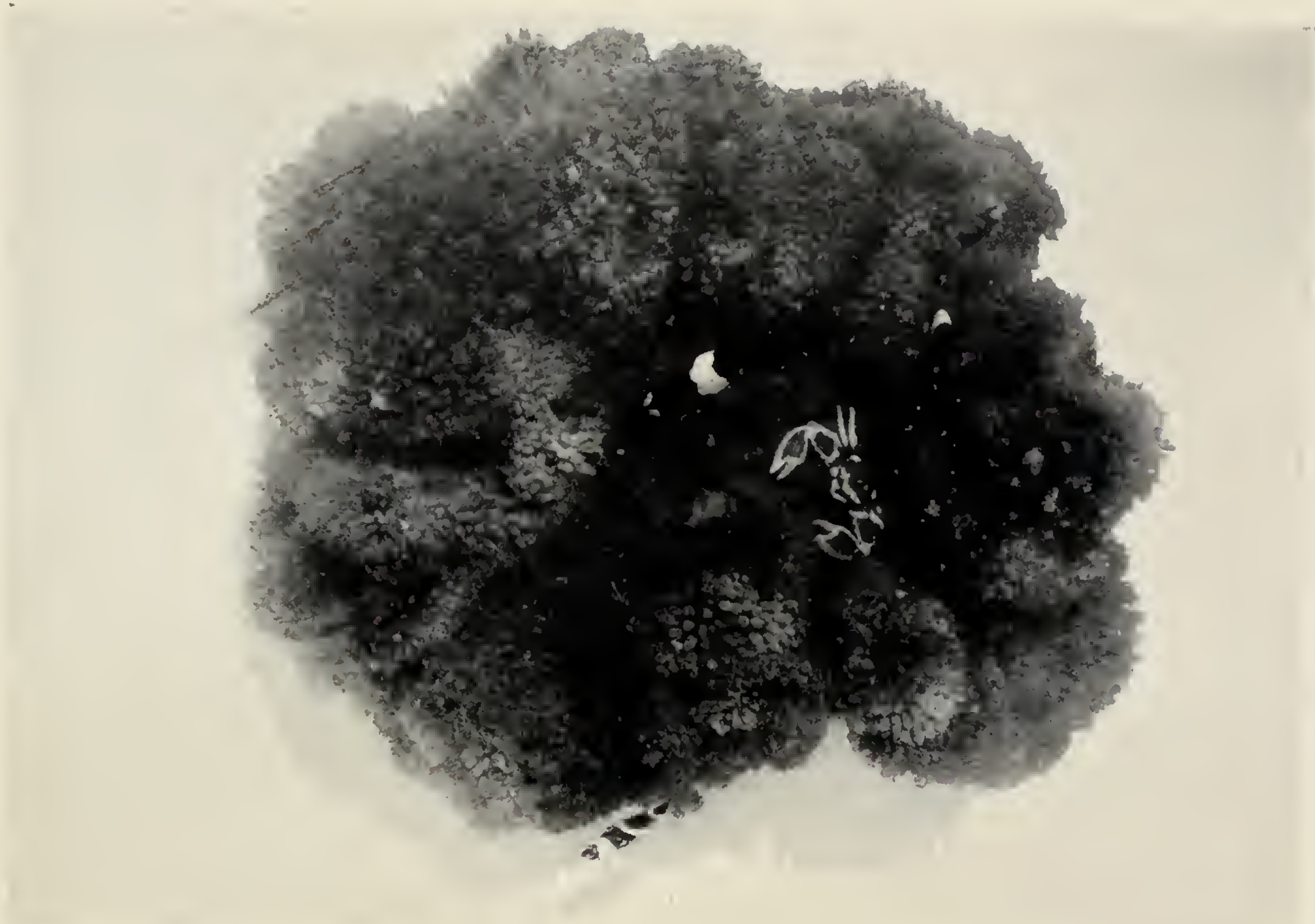

PLATE 18 ANEMONE (STOICHACTIS) AND AMPHIPRION. Page 60

Amphiprion is a fish that is allowed to take shelter in the Anemone's mouth.

Photo by W. Saville Kent.

could pierce his scales and flesh and rapidly kill him—we are astonished alike at the fish's fearlessness and his immunity from destruction. His ground-colour is orange-vermilion, across which run three bands of white bordered with black—a very noticeable style of colouring in open water, but perhaps not so striking in its chosen environment. The wonderful thing is that, not only does the Anemone refrain from molesting the fish, but receives it in a friendly way into its mouth when any danger threatens it. The danger past, the fish swims out unharmed. In the same dangerous position, but among the tentacles of another of these large anemones, we find a prawn of somewhat similar, and equally striking, coloration. There is clearly a very definite understanding in both these cases, otherwise the lives of fish and prawn would not be worth five minutes' purchase. One point that such an association seems to make clear is this—that these lower forms of life must possess a higher grade of intelligence than it is the fashion to credit them with. Both fish and prawn are the natural prey of Anemones. How are these particular Anemones able to distinguish between this fish and this prawn and those of other species that it certainly would kill and eat if they came within

striking distance? It is all very well for the psychologists to say on theoretical grounds that below the higher vertebrates there can be no reasoning, no consciousness of what they do or why they do it, but facts like these are all against their theories.

One section of the Anemones—Zoanthidæ—form little colonies, attached to a stolon or runner of flesh which creeps along the rock or other base, and forms at intervals buds which develop into adult anemones, but still remain connected with the stolon. Certain of these we shall have occasion to mention when we come to the Hermit Crabs and their friends; but many of the species are also what is known as epizoic in character. That is to say they live attached to other animals, whether the association is truly symbiotic or not. *Parazoanthus anguicomus*, for instance, a species that is found in rather deep water off the Shetlands and the West of Ireland, is usually found attached to various species of Sponge. *Parazoanthus tunicans*, like *Gephyra dohrnii* attaches itself to the stems of a hydroid—in this case *Plumularia*—and *P. separatus* is found on the coast of Jamaica associated with a sponge; whilst *Epizoanthus stellaris*, as we have seen, encrusts the rooting tuft of *Hyalonema*.

Tubularia, which has been mentioned as the host of the Anemone, *Gephyra dohrnii*, has been reported as commensal with a Cuttle-fish.

The order of Corals known as Millepores—as well as some other Corals—contain in their superficial canals and in the zooids that inhabit them, an abundance of the Zooxanthellæ that we have mentioned as inhabiting sponges. It has been contended that these corals obtain all their nutriment from the activity of these yellow Algæ, but it is known that certain of the zooids catch and kill living animals, and it is not reasonable to suppose that they do this for mere sport. In Millepore there are two kinds of zooids, called dactylozooids and gastrozooids, which inhabit pores of different sizes. If the unbroken surface of a piece of Millepore coral be examined it will often be seen that there is a definite order in the arrangement of these pores. A large pore is surrounded at a little interval by a ring of five or six smaller pores. But even if this order is not observed and the two kinds appear to be scattered indiscriminately, it is easy to detect the difference by size alone. The gastrozooids inhabit the large pores, and the dactylozooids the small pores. These zooids remain in the pores by day, but occasionally they have

been seen extruded, and it is believed that they are only active at night. The dactylozooids capture living food and are provided with stinging threads for the purpose. The digestive function is performed by the gastrozooids. As the Zooxanthellæ, being plants, can only work in sunlight the Millepores are only found in shallow water where sunlight can reach them. They, no doubt, supply the Millepore with carbohydrates and in turn utilize their nitrogenous waste.

The large Jelly-fishes (*Medusæ*), which belong to this class are well-known for the possession of stinging-threads, by means of which they capture their food. Yet, in spite of this dangerous character, they give shelter under their umbrellas to certain selected friends, who are thus protected from larger creatures that would make a meal of them but for a wholesome fear of the Medusa's stings. Most of these jelly-fishes, it is true, have very small mouths, and it is reasonable to suppose that they could not make use of their guests as food even if they killed them. Others, however, are known to consume small fishes, crustaceans, and sea-worms, whilst others again confine their attention to their own relations, the smaller jelly-fishes that arise from the Hydroid Zoophytes and Millepores. Yet, so large

PLATE 19 RHIZOSTOMA AND YOUNG FISHES. Page 64

A large Jelly-fish that will shelter as many as a hundred small fishes.

By T. Carreras.

a species as *Cyanea capillata*, popularly known as the Stinger, constantly shelters the young of the Whiting (*Gadus merlangus*). *Rhizostoma pulmo*, another large species, though one that scarcely stings, has been found to have more than a hundred of the fry of the Horse Mackerel (*Caranx trachurus*) under its protection at one time. According to Agassiz, the American species of Jelly-fish known as *Dactylometra* is always accompanied by a species of the herring family and the young of the Butter Fish (*Stromateus*); but it is doubtful whether this association is altogether a friendly one, for it is said that the fishes often nibble at the fringes of their protecting umbrella and feed on the Medusa's eggs, and that the Medusa occasionally helps himself to one of his followers.

Around the shores of New South Wales there is a fish, known as *Nomeus gronovii*, but which is only found when a fleet of the Portuguese Man-of-War (*Physalia*) gets driven ashore by a strong wind. The fish swim beneath the *Physalia* just as the young Horse Mackerel do beneath the umbrella of Rhizostoma. This is scarcely an even-sided arrangement, for it is not easy to see what advantage the Physalia derives from it; yet it is clear that the Physalia is a consenting party or the Nomeus

would cease to exist, for the Physalia feeds on fish and the European species is said to kill and consume fishes as large as a full-grown mackerel. There is probably some advantage to the Physalia which has not yet come to light. It is quite certain that the fish must seek the company of the jelly-fish, and would swim away if they were in any danger, for they have the voluntary use of their fins, whereas *Physalia* must float where the winds or the currents take it. White says: "If the fish secures safety from its enemies by entering the area embraced by the deadly tentacles of the *Physalia*, which attain a length of ten to twelve feet, it must be immune to their influence; a remarkable condition, considering that small fish have often been seen in their stomachs and entangled in their tentacles. . . . It is probable that, in addition to protection, the fish derives its food from association with the *Physalia*, much as does a Remora in accompanying a shark. The Physalia doubtless paralyzes many more animals than it can consume—the residue falling to the lot of the fishes, which may be present to the number of ten."

A little coral named *Heteropsammia aphrodes*, one of the Madrepores, found off the coast of Ganjam in twenty to twenty-five fathoms, has a worm-

messmate, who occupies a chamber in the interior. The coral, of course, were it of an unfriendly nature, could close up the entrance to this chamber by new growth; but it does not. Near the base of the coral a neat opening is always left for the worm, so that he can enter or leave at his pleasure. The basis of this partnership appears to be that the coral hides the worm, whilst the worm pulls the little coral mass about to fresh feeding-grounds. Alcock succeeded in keeping them in confinement for a time, and so was able to determine this point.

Another species of Heteropsammia (*H. cochlea*) and an allied Madreporian coral (*Stephanoceris rousseaui*) live on the shells of certain molluscs in the vicinity of Aden. In the same neighbourhood occur two species of Gephyrean worms named *Aspidosiphon heteropsammiarum* and *A. michelini*. The Gephyreans at an early age take up their abode within their respective hosts, and provide for their increasing bulk by building a coiled tube of lime, the outer surface of which affords space upon which the coral can continue its growth.

A similar association of worm and coral is found in the case of *Mycedium fragile* (coral) and a tube-building worm. The tube, which, like the coral, is composed of lime secreted by the worm, runs along

the underside of the young coral, and its mouth keeps near the rim of the saucer-like coral. But the coral grows around it, and soon completely invests the tube, but the worm ever lengthening this keeps the mouth still free. Of course, should the coral grow up over the mouth of the tube the worm would die; but this rarely if ever happens. In some cases the tube has so turned that it rises above the upper surface of the coral, but the coral spreads up its exterior, and so brings about an irregularity of the coral surface.

V

MOLLUSCS AS HOSTS AND LODGERS

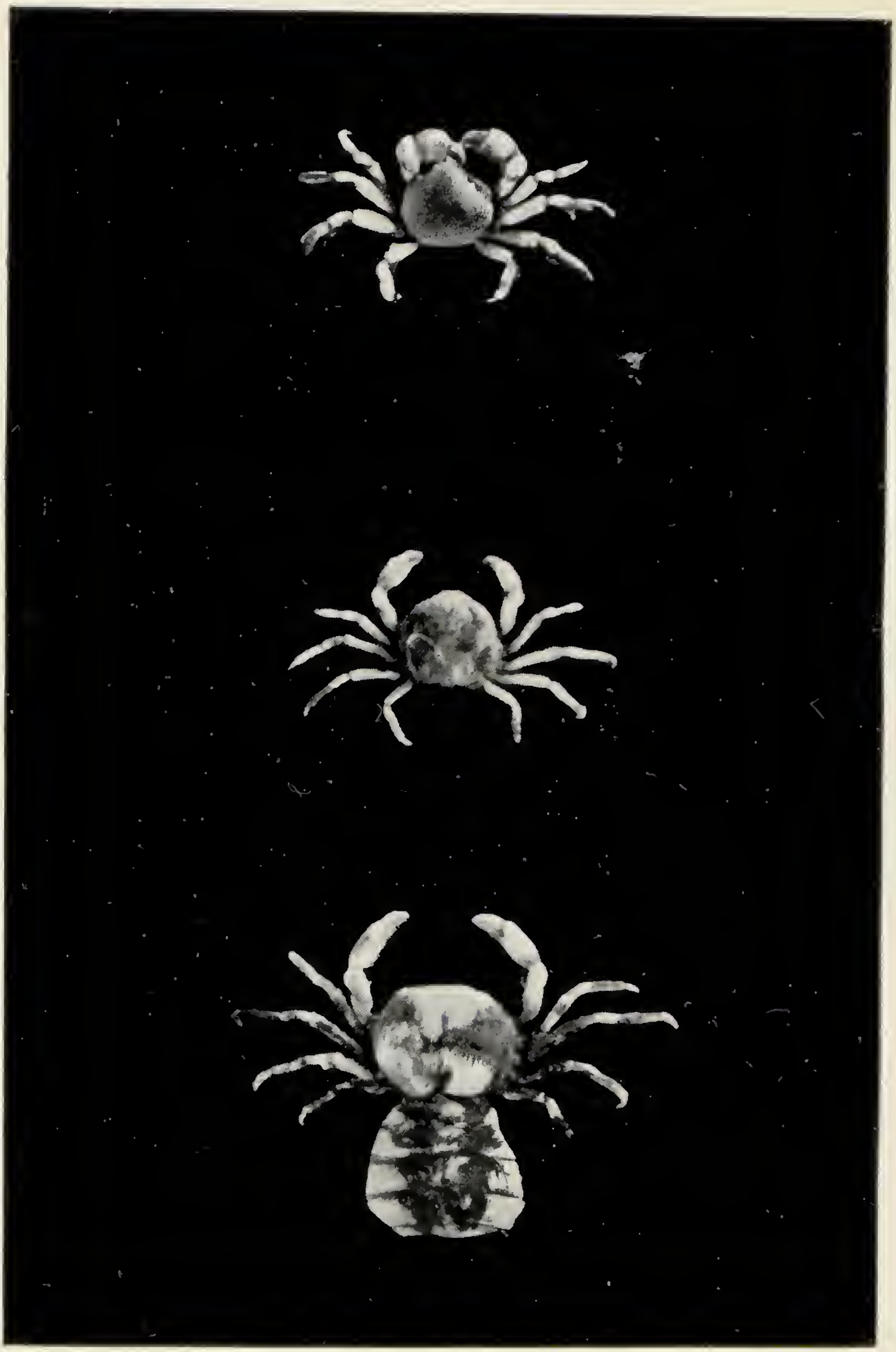

PLATE 20 PEA CRABS. Page 71

The upper figure is a male of Pinnotheres pisum; below it the male and female of Pinnotheres veterum.

Photo by Author.

V

MOLLUSCS AS HOSTS AND LODGERS

Considering how clever as architects and builders the greater part of the enormous tribe of Molluscs —the so-called "Shellfish"—have proved themselves to be, and how permanent are the structures so many of them fashion, it is not surprising to find that some less-protected and smaller creatures have considered it good policy to make friends with them. The basis of the arrangement—on one side, at least—is obvious. There are few enemies that can successfully assault the stony castles erected by many of the marine species, and, as a rule, they are strong enough to withstand the buffeting of the most terrible storms.

Probably the most remarkable of these associations between Molluscs and other animals is that between the little Pea-Crab (*Pinnotheres*) and the Mussels of various kinds. This is not one of the discoveries of modern science. The partnership was a fact well known in the earliest days of literature, and the writings of ancient philosophers may

be quoted in support of this statement. It is true that these early observers came to wrong conclusions as to the nature of the arrangement, but that may be said of every one of such cases up to a generation ago. The ancient Egyptians in their hieroglyphics made use of the mollusc (*Pinna*) and this crustacean as a symbol of friendship, and the Greek and Roman poets and philosophers had a good deal to say of it. In truth, one is inclined to devote a whole chapter to *Pinna* facts and fancies, and is only constrained by the reflection that it would cause this book to be somewhat lop-sided. A brief glance at these facts and fancies, however, will probably be welcome to the reader. First for the facts.

One of the smallest of our crabs is known from its minuteness and roundness as the Pea-Crab (*Pinnotheres pisum*). A common characteristic of the crab family is that their shelly armour, both of body and limbs, has a strong tendency to run out into sharp angles and spines, apparently to make themselves as unpleasant as possible to their numerous enemies. The Pea-Crab, in strong contrast to this prevailing character, has all the edges rounded and polished, and there is not a single spine or prickle to be found upon it. Not only so, but

PLATE 21 PEA CRAB IN SHELL OF MUSSEL. Page 72

One valve of the Mussel's shell has been removed to show the Pea Crab in situ. Enlarged.

Photo by W. B. Randles.

instead of the "shell" developing the usual stony hardness, it is soft, like a covering of wet thin parchment. I believe that the female of the Pea-Crab has never been taken roving at large in the sea. Her small and insignificant mate has—probably when he has been searching around for a wife. The males are in a very distinct minority, and it is very likely that they are polygamists. There is a general delicacy and daintiness about these crabs which tells you at a glance that they have not been built for the rough life of the open sea. Possibly, it was some such primitive feebleness that originally led them to seek the calm haven of a bivalve's shell; but it is much more probable that their present condition has been brought about gradually by their secluded habits making hard thick shells and defensive spines unnecessary. Nature does not go on producing structures that changed habits have rendered unnecessary.

The old notion appears to have been that the Pea-Crab was a crafty fellow who waited until he saw the *Pinna* open his valves for the purpose of admitting the submarine equivalent of fresh air, then picked up a pebble and inserted it between the valves to prevent their closing. Then he forced his way inside and began to eat the mollusc

out of house and home. Oppian has put another idea into verse in his *Halieutics*, as witness the following translation, which we take from Pennant (1777):

> "In clouded deeps below the *Pinna* hides,
> And through the silent paths obscurely glides;
> A stupid wretch, and void of thoughtful care,
> He forms no bait, nor lays the tempting snare.
> But the dull sluggard boasts a crab his friend,
> Whose busy eyes the coming prey attend.
> One room contains them, and the partners dwell
> Beneath the convex of one sloping shell;
> Deep in the wat'ry vast the comrades rove,
> And mutual interest binds their constant love;
> That wiser friend the lucky juncture tells,
> When in the circuit of his gaping shells
> Fish wand'ring enter; then the bearded guide
> Warns the dull mate, and pricks his tender side;
> He knows the hint, nor at the treatment grieves,
> But hugs th' advantage, and the pain forgives:
> His closing shells the *Pinna* sudden joins,
> And 'twixt the pressing sides his prey confines;
> Thus fed by mutual aid, the friendly pair
> Divide their gains and all the plunder share."

Oppian calls the Pea-Crab *Pinnophylax*. Aristotle, Cicero, and Pliny also refer to the association and take the view that it is based on an understanding between the partners for their mutual advantage. Aristotle called the crab *Pinnoteres*, meaning the Pinna's guardian—a name that La-

treille unfortunately changed to *Pinnotheres*, which is the present scientific name, and signifies the Pinna hunter. The *Pinna* is a bivalve shell of large size found in the Mediterranean, and therefore best known to the ancients as the host of the Pea-Crab; but on our own coasts two species of the crab are fairly plentiful in Horse Mussels (*Modiola*), also in the Common Mussel (*Mytilus*) and other shells.

Naturalists for hundreds of years, from the days of Gesner onwards, have pointed out that Oppian's view of the relationship was a little bit incorrect in that *Pinnæ* and Mussels do not feed upon fishes or other solid prey. Another popular notion long current, and still to be met with, is that the poisonous effect of Mussels as food is solely due to the presence of the Pea-Crab, who gets eaten with the bivalve. Pennant, as far back as a hundred and thirty odd years ago, scouted this idea, for he says it "unjustly has acquired the repute of being poisonous. The swelling after eating of mussels is wholly constitutional; for one that is affected by it, hundreds remain uninjured." So far from there being any probability of the inadvertent swallowing a Pea-Crab or two being attended by any unpleasant results, Say tells us of a species that is found in the American

Oyster (*Ostrea virginica*) that those who are fond of oysters rarely reject the crab, and that where the fresh oyster is opened in considerable numbers to be eaten, the crabs are carefully separated, in order that many of them may be served up by themselves to gratify the palate of the gourmand. Patrick Browne in his "History of Jamaica" tells us of a species he calls the Oyster Crab, because it is found in the shells of the Mangrove Oysters, that "such as eat the oysters do not think them a bit the worse for being accompanied with some of these crabs, which they swallow with the fish (!)."

There is no doubt that the currents set up by the mussel to bring microscopic food to its mouth bring larger particles that would be a nuisance to the mollusc, but serve as food for the crab; and that the crab by uneasiness on the approach of a possible enemy may give notice to the mollusc that it is time to close the shell, or may more actively defend his host by destroying and eating some would-be parasite. It is at least fairly clear that the mussel suffers no injury from the presence of the crab. It would really appear as though the fashion of taking in a lodger or paying guest has spread from the Pinnas and Mussels to other molluscs, for other species of Pinnotheres are

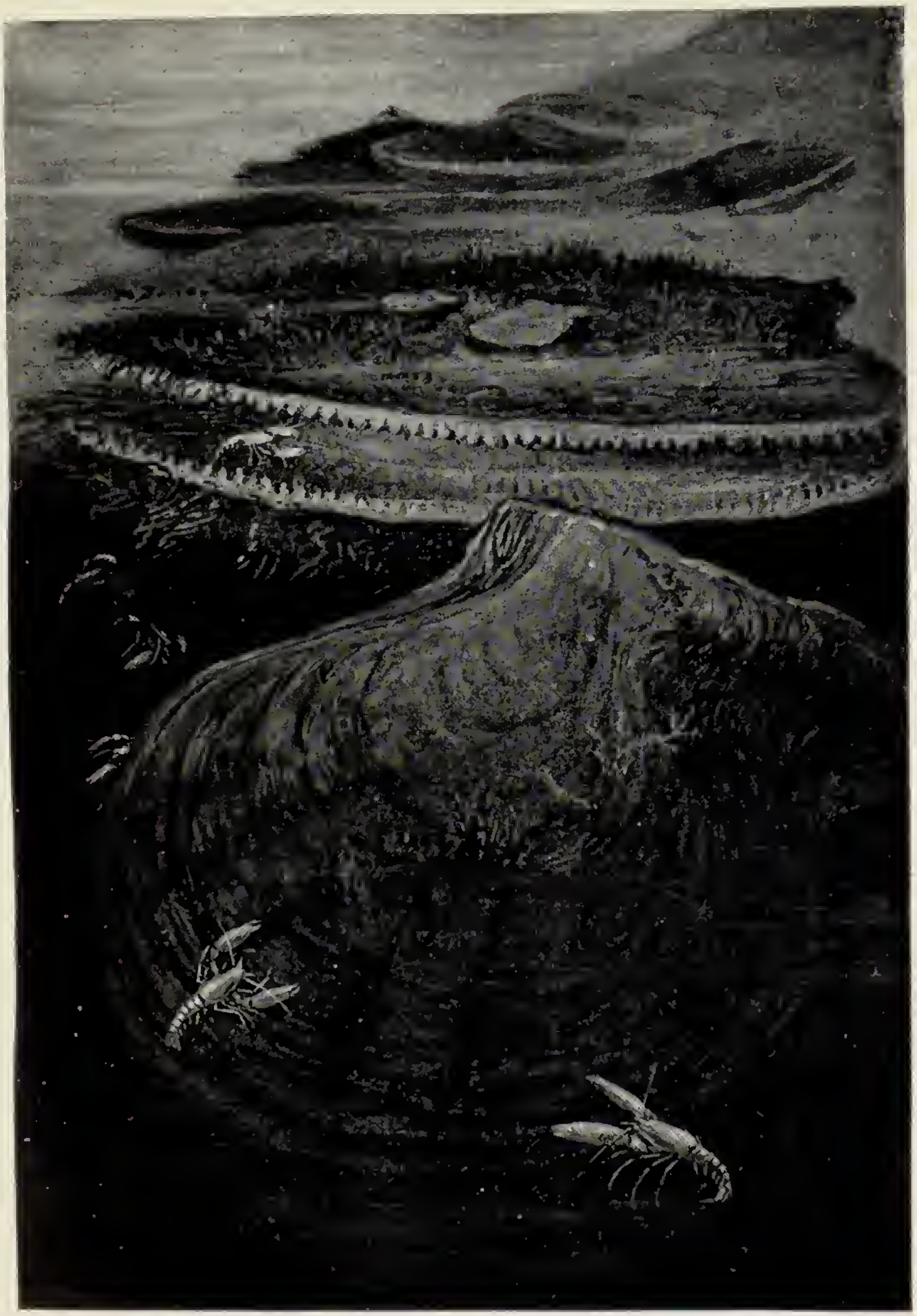

PLATE 22 PEARL OYSTER AND PONTONIA. Page 76

In the upper figure the Pearl Oyster is shown with its shell slightly open revealing the shrimp inside.

By T. Carreras.

found lodging with different molluscs in various parts of the world. In Japan the *Pinnotheres pholadis* is found in the rock-boring *Pholas* or Piddock; *P. lithodomi* in *Lithodomus* of similar habits in North America. Another one frequents the Pearl Oyster, and one of the crabs has been found encysted in a pearl. This was probably due to the death of the crab, an instance of the Pearl Oyster disposing of what might prove noxious to its health by sealing it up, most pearls having a somewhat similar origin. In the Indian seas *Pinnotheres purpureus* has been found in a species of Oyster; and *Pinnotheres mactricola* in one of the Trough-shells (*Mactra violacea*).

Another species of crustacean—but a shrimp (*Pontonia meleagrina*) instead of a crab—is also found in the Pearl Oyster and in the Giant Clam (*Tridacna*). At the Azores *Pontonia custus* constantly inhabits the shells of *Pinna rudis*.

The Gaping File-shell (*Lima hians*) is remarkable in that it builds a sort of nest by weaving together stones and shells and corallines with its byssus-threads. The nest usually contains in addition a tiny crab known as the Porcelain Crab (*Porcellana longicornis*), who apparently acts the part of a housemaid, keeping the house clean and eating

up all waste. In this work the crab is frequently assisted by a fellow guest, one of the Sea-worms (*Polynoë*), a broad flat worm whose back is covered by a number of armour plates.

Among the smallest of our bivalve shells are the Montagu-shells, of which full-grown specimens only measure a quarter of an inch. Two species of this genus are noted for their friendliness to Sea Urchins of a particular type. One of these molluscs—Montagu's Urchin-shell (*Montacuta substriata*), an almost transparent creature (both animal and shell), can only be found in one habitat. It is vain to seek it on the rocks or sand or seaweeds. If you would find it you must dig up one of the burrowing Heart Urchins (of which we have three species), and you will find it attached to the spines. Considering that these Heart Urchins spend the whole of their lives burrowing in the sand, scooping it up with their mouths and merely digesting out what organic remains may be mixed up with it, it does not appear to be a very cheerful life that the Urchin-shell has chosen; but there it is of its own free will, and apparently it shares the particles of food that the passage of the Urchin through the sand brings to it. A congener, the Rusty Montagu-shell (*M. ferruginosa*) is of very similar

habit, living in the burrow of the Heart Urchin, and often attached to its silky spines.

The little Scaly Coin-shell (*Lepton squamosum*) has a somewhat similar habit, though instead of an Echinoderm it chooses a quaint Crustacean for its messmate. This host is a lobster-like shrimp named *Upogebia stellata*, and it has the habit of burrowing like a mole-cricket in the muddy sands of certain of our shores. In these burrows also dwells the little bivalve named, which, to fit it for its environment, has made its valves very flat and coin-like, so that it shall not obtrude too far into the fairway of the burrow and cause a wedging of the crustacean when for tactical reasons it makes a hasty retreat into the deepest recesses of the burrow. The bivalve lives upon the surplus food and waste of the *Upogebia*, and so keeps the home sweet and tidy.

In recent years the oyster beds in the Thames estuary and at the mouths of tributary rivers, have been infested by an alien mollusc known as the Slipper Limpet (*Crepidula fornicata*), introduced, it is believed, with barrelled oysters brought from North America for the purpose of re-laying in English beds. They have now become thoroughly naturalized and have multiplied to such an extent

as to become a serious nuisance to the oyster farmers. At first they were thought to be enemies like the Starfish and the Sting-winkle or Whelk-tingle—the first forcing the shells open and digesting the oyster whole, the second boring through the shell and eating him piecemeal; but it is now known that the Slipper Limpet and the Oyster are merely mutualists who like each other's company, but do not appear to assist each other in any way. The nuisance to the oyster-man consists in the fact that additional labour is requisite in order to clear the Slippers off the Oyster's shell before it goes to market. Like the Common Limpet, the Slipper likes to return to the same perch for resting, but instead of sinking a shallow pit on the rocks, one attaches itself to a rounded pebble whose convexity fits into its shell, whilst a second Slipper perches on the first, and so on to the number of seven or eight. Dr. Murie, in a communication to the Linnean Society (November 2, 1911) speaks of them as "partaking of the oyster's food," but this is not very probable, seeing that the oyster is a bivalve and able only to feed on microscopic organisms, whilst the Slipper is a univalve with well-developed ribbon-teeth adapted for cutting and rasping more solid food. It is more likely

that, like the other limpets, it ranges around rasping seaweeds and returning to its roosting-place for rest. Possibly its companionship with the oyster may be due to its finding the most suitable food growing on the upper valve of the oyster-shell.

The Eulimas are a remarkable group of small awl-shaped polished shells that one can almost see through. They have given up the production of rasping teeth, owing to their having taken to soft substances for food. They have in some cases become messmates, in others parasites, feeding upon the waste of their hosts, or sucking their juices. They attach themselves for this purpose to the persons or houses of other molluscs or to Sea Cucumbers (*Holothuria*), and Sea Urchins (*Echinus*). One of this group is known as the Urchin Shell (*Stilifer turtoni*), because the only place in which it has been found is among the spines of the Sea Urchin, upon whose excrement it feeds. Owing to the fact that the exit from the digestive tract is at the summit of the Urchin's shell the Echinus has had to develop a special set of organs (pedicellaria) with forcep extremities, partly for the purpose of clearing off excreta and partly for warding off the attacks of enemies. Any help it can get in either case would probably be

appreciated; so that we may regard Stilifer as a true messmate. Some of the Pyramid-shells (*Odostomia*) have similar habits, and hang about the excretory passages of fellow molluscs.

There is a remarkable mollusc named *Mágilus* found in the Red Sea and at Mauritius. In early life its form is not unlike the shell of the Dog Winkle of our own shores. But it takes to living on the Madrepore Coral; whether as a messmate or a parasite is not clear, so we give it the benefit of the doubt. Owing to the rapidity with which the coral grows, the shell gets fixed and would soon be sealed up in the growing mass but for the fact that the mollusc extends his own shell as a straight tube, always keeping pace with the growth of the coral. It has to advance up this tube in order to be able to lengthen it, and it fills up the lower part with a stony core as it advances; so we see it in museums with the original shell about two inches long attached to this tube of a foot or fifteen inches. So remarkable is this tubular outgrowth that Lamarck decided it must be a tube-building worm, like *Serpula*, and classed it accordingly.

Alcock found off Cape Comorin, in more than a thousand fathoms of water, a spindle-shaped sea-snail (*Pleurotoma symbiotes*) covered with the

PLATE 23 MAGILUS IN CORAL. Page 82

To prevent being sealed up in the growing Coral, Magilus extends its shell into a long tube, keeping pace with the growth of the Coral.

By T. Carreras.

encrusting Anemone, *Epizoanthus*, a species very similar to that which in the North Atlantic covers shells containing some of the smaller Hermits. Those are partners with the Hermit, the shell having been vacated always by the death of the Mollusc. The present case is quite different, the partner being the living Mollusc by which the shell was fashioned. If the statement had been founded on an isolated instance we might have supposed, quite reasonably, that the Anemone had made a mistake and fancied the shell was tenanted by a Hermit; but Alcock assures us that although other Indian species of Pleurotoma are not similarly affected, *Pleurotoma symbiotes* has *never* been found without this messmate.

Between the large Freshwater Mussels of lakes and streams and the Bitter Carp or Bitterling (*Rhodeus amarus*) of Central Europe there is a strange exchange of civilities during their breeding season. Each party to the arrangement agrees to the other becoming wet-nurse or foster-parent to its progeny. The large Swan Mussel (*Anodonta cygnea*) and the River Mussels (*Unio*) lie in the mud with their valves partly open, to receive the microscopic food that comes in with the flow of water set up by the movements of cilia on their gills. Their

young have a peculiar (probably primitive) type of shell, each valve of which is provided at its tip with a strong sharp hook which enables them to cling securely to the fins or flesh of fishes, in order that they may make their way in the world and not overcrowd the spot where they were born. The female Bitterling in the breeding season develops a long orange-red ovipositor, two-thirds of her entire length, which might be mistaken for a worm escaping from her body. She introduces the tip of this into the open shell of the mussel, and through it deposits her eggs in the gill-folds of the mollusc. The eggs hatch and the infant fish remain between the gill-plates until they have grown large enough to take care of themselves outside. Altogether, the mollusc has to act as nurse for a month. That is one side of the transaction; but whilst Mrs. Bitterling was busy with her egg-placing, Mrs. Anodonta was not asleep. Had she liked she could have closed her valves with a snap and so have bitten off the bright ovipositor. But she kept her valves open and directed a stream of her own embryos upon the fish, where they fixed their hooks into fins and flesh and remained attached for about the same period as their mother was charged with the care of the larval Bitterlings.

PLATE 24 BITTERLING AND SWAN MUSSEL. Page 84

The Bitterling deposits her eggs between the gills of the Swan Mussel. At the same time the embryo Mussels are cast out and attach themselves to the fish.

By T. Carreras.

VI

CRABS AND THEIR KIND AS HOSTS

VI

CRABS AND THEIR KIND AS HOSTS

We have already given a hint or two of the high estimate which a long and intimate acquaintance with Crabs has caused the writer to entertain of their intelligence and the practical application of it. This is not the place in which to give anecdotes in support of our view, but we think that a few plain statements of partnerships they have effected with various other forms of life will tend to incline the reader to share our view.

Prominent among the Crustaceans for the clever arrangements their ancestors in remote times must have made, and in later generations maintained, are the Hermit Crabs. We know that they are an ancient family because they have divided off into a number of branches, and each branch has numerous living representatives which differ from each other in some respects, and have made similar bargains with different messmates.

To properly understand the position of the Hermits before they took to the practice of thrusting their hind bodies into shells one must see a Hermit extracted from its house, or watch one that is removing to new premises. We should then see that for all the brave front a housed Hermit presents with its rough armour-plated limbs, Nature has treated it very scurvily in leaving all its hind parts covered only by a soft skin, and therefore in a condition that actually invited attack. It has been suggested that this condition of things has really been brought about by degeneration following upon the housing habit; but it is not likely that any crab with a continuous shelly covering would have attempted so to dispose of its body. Besides, there are several examples that have been left in somewhat similar condition which have never taken to the housing remedy, and from them we may learn that in this particular group Nature did leave her work unfinished. One well-known example is the Coco-nut or Robber Crab of the East, but this has horny plates over its hind parts which afford some protection. However, the Robber Crab would not trust itself in the sea, where Crustaceans have enemies all around them, but took to the land and learned to subsist on the flesh

PLATE 25 COMMON HERMIT CRAB AND "PARASITE" ANEMONE. Page 88

The Anemone perches on the whelk-shell tenanted by the Hermit and is carried over the sea-bottom.

Photo by Author.

of the Coco-nut, resting in holes in the ground where it could keep its less protected parts hidden whilst it blocked up the entrance with its formidable nippers. Sometimes it thrusts its tail into a coco-nut shell and goes about on land much as a Hermit crab goes about in the sea.

The best-known of these Hermits is the Soldier Crab or Common Hermit (*Eupagurus bernhardus*), which in its smaller sizes may be found in all the rock-pools, or dragging winkle shells along the shore. The full-grown individuals are too conspicuous for such a habitat, so they betake themselves to deeper water where they can find full-sized whelk-shells which alone are large enough to shelter them. Now, in this deeper water there are big fishes who appreciate crab as a food, and who have palate teeth powerful enough to crack the crab's armour. So the Hermit has had to enter into an *entente* with a creature whose perpetual presence will make the crab appear to be anything but a desirable mouthful for the fish. This distasteful creature is a pale-brown anemone, which the earlier naturalists, mistaking the nature of its fellowship, dubbed the Parasite (*Adamsia rondeletii*). This anemone perches on the smaller end of the Hermit's whelk-shell, and sometimes he has one,

two, or even three of his own species to keep him company—though in this last case it always struck us that the shell was a bit overcrowded. This was especially so when the anemones had erected themselves to their full dimensions and expanded the broad crown of tentacles.

When the Hermit withdraws himself into his cell his big right hand—which is twice the size of the left—effectually closes the mouth of the shell, and he may, therefore, appear to be quite safe from molestation by enemies. But there are a few big-mouthed fishes who would not scruple to crush a strong whelk-shell for the sake of getting a full-sized Hermit Crab to eat; and it is here that the Hermit's wisdom is seen in making a friendly deal with the Anemone. A few of the smaller anemones are attacked by some of the sea-slugs, otherwise they appear to be left severely alone, owing to an objectionable secretion from their skin. They are also provided with stinging threads, but these might not be sufficient to deter a large well-scaled fish. However, they *are* left in peace, and the principle underlying the treaty between the Hermit and the Anemone is that a crab-loving epicure among the fishes will pause if he knows that he cannot get his crab *au naturel* but must take it

PLATE 26 COMMON HERMIT CRAB AND NEREIS. Page 90

A beautiful sea-worm, six or eight inches long, shares the Hermit's cell, and acts as housemaid.

Photo by Author.

accompanied by anemone. The consideration received by the anemone for services rendered in this way is free carriage to the best feeding-grounds and a share of all that is going in the food line. The ordinary anemones, perched upon the rocks, have to wait until something eatable blunders against their tentacles; the Hermit's friend can help himself, and, so to speak, eat out of his partner's dish. For it must be understood that he is not always maintaining the erect, tower-like attitude shown in the photograph. When there is food about he can bend down to it, and sweep the ground if necessary.

It is remarkable how thoroughly the Anemone has adapted its life to this commensal habit. The other species you may find on the rocks and in the pools, but this and the allied Cloaklet Anemone you will not find except on shells occupied, or recently tenanted by Hermit Crabs. On the death of its partner it immediately moves off the shell, and sits on a stone until some other Hermit in need of a companion comes that way, when it mounts his shell.

If you transfer one of these Common Hermits to an aquarium in order the better to observe its ways, you will find before long that the Anemone

is not its only partner. At feeding time you will see the head and an inch or two of the body of a beautiful sea-worm creep out of the shell and over the Hermit's head to claim a part of the meal. He is one of the group called Polychæta, and is known as *Nereis fucata.* A full-grown example is six or eight inches in length, but there is plenty of room for him in the unoccupied spiral coil of the whelk-shell. His body consists of a great number of joints, each bearing a pair of bristle-like feet. As his name *fucata* implies, he is beautifully painted, red with two white stripes, and the varying colour effects are heightened by iridescent gleams. He is mainly carnivorous, but it is probable that he also feeds on any garbage that comes along, and that his share of duty in the partnership is to keep the interior of the house clean. But, like a cat, he appears to be more attached to the house than to the owner. I do not know what happens if the Hermit removes to a new house; but if the Hermit dies, instead of vacating the house as the Anemone does, the Nereis stays on for months.

Another joint-occupier of the Hermit's house is a Hydroid Polyp, known as *Hydractinia echinata.* So far as anybody has yet made out, he is not a

PLATE 27 — POLYPS OF HYDRACTINIA. — Page 92

A colony of these Hydroid Polyps lines the mouth of the Hermit's cell. Greatly enlarged.

member of the partnership, but a mere self-invited non-paying guest. He spreads himself around the mouth of the shell, both within and without, and the hard spines he constructs between his soft polyps may be useful in partly filling up the doorway if the shell is too large for the Hermit. He may also waylay minute creatures that would be an annoyance to the Hermit if they got in and attacked his soft parts; but at present there is no definite evidence in this direction, so his presence may be considered as fortuitous. At the same time it should be stated that almost the only place in which to find it is on a shell that is tenanted by a Hermit; and as we shall see, there are cases in which there can be no doubt of its usefulness to another member of the hermit fraternity.

Almost as large as the Common Hermit is Prideaux's Hermit (*Eupagurus prideaux*), a species that is given more to housing itself in a discarded Top-shell (*Trochus*). It is not necessary to enter into the details of structure which distinguish Prideaux from Bernhardus, for they are such as appeal only to the naturalist, whilst to the non-naturalist there is little difference between them. But see how the naturalist is supported by Nature! The

naturalist separated these two species on structural grounds alone, many years ago, when these anemones were regarded as mere fortuitous parasites on the Hermits. The two Anemones know the difference without consulting the naturalist's diagnosis; and you will find *Adamsia rondeletii* perching on the house of Bernhard, and *Adamsia palliata* folding its mantle round the house of Prideaux, and not *vice versa.*

This Cloaklet Anemone is so called because its body, instead of being columnar as in most of the species, is developed into two spreading lobes which fold round the Hermits' shell and meet on the other side. Here is pretty conclusive evidence of an adaptation continued through centuries which has brought about the fact that the Cloaklet is now unfitted for any other situation. You may find Rondeletii temporarily attached to stones whilst he is on the look-out for a new partner, but Palliata either dies when his partner dies or clings to the empty shell till a new tenant takes possession. He has rarely been found in any other situation, and in these cases it is reasonable to suppose that he was only temporarily off the shell he fits so well. Neither of these two Anemones falls to the lot of the longshore collector; they

like deep water and must be sought with the dredge a mile or two from land.

In the cells of *Eupagurus prideaux* at Naples, an Amphipod crustacean allied to our freshwater shrimp is almost always found; probably doing housemaid's work for him.

The two Hermits we have described are our two largest species; we have several others of smaller proportions, and they all appear to have messmates of some sort—such remarkably sociable hermits are they. One of these smaller kinds is the Downy Hermit (*Eupagurus pubescens*), whose special taste in coverings is for a great-coat consisting of the compound anemone *Epizoanthus incrustatus*. This species completely surrounds the hind body of the Hermit, and to permit of the growth of the crab it increases its own size by budding, but keeps the bodies of itself and scions still connected. Thus you find the Downy Hermit's head protruding from the united bodies of from six to twenty anemones, each of which shows its individuality by maintaining a short columnar outgrowth from the mass terminating in its crown of conical tentacles. First of all the Hermit pushed his hind parts into a little Necklace-shell (*Natica alderi*), upon which the *Epizoanthus* settled and

spread; but if you are curious enough to hunt for this shell inside the colony of Anemones you will only find a hollow corresponding in shape to it. The Anemone has dissolved the shell, but in order that the Hermit shall not miss it, the exact form is maintained, however the Anemone colony may grow. A specimen of the Downy Hermit in our possession is housed in an Auger-shell (*Turritella communis*) and is further protected by the shell being completely covered by the Hydroid, *Hydractinia echinata*, as shown in the photograph. When the photograph was taken neither crab nor Hydroid was alive, so the polyps of the latter are not visible—only the stony spines it builds between the polyps. These, in conjunction with the stinging threads which all these Hydroids possess, should serve as a protection to the little Hermit.

The Hairy-handed Hermit (*Eupagurus pilosimanus*) is similarly enwrapped in a similar species of Anemone, to which has been given the name of *Epizoanthus paguriphilus*, the second word meaning "crab-lover," because it is never found except in association with this particular Hermit. Crab and Anemone are found in deep water right across the North Atlantic from the north-east coast of America to north-west Europe, and down south

PLATE 28 DOWNY HERMIT CRAB IN SHELL COATED WITH HYDRACTINIA. Page 96

In this case the Polyps cover the exterior of the shell, and by making it spiny give the Hermit additional protection.

Photo by Author.

certainly as far as the Bay of Bengal, where it has been taken at depths between 1,600 and 2,000 fathoms. It is indeed a true abyssal species, only found in deep waters. Seeing that this anemone is never found apart from the crab, it might be thought that the Hermit began life by getting the Anemone to take possession of his hinder integuments; but this is not so. Minute examples have been found by various investigators, and it is clear that the association is begun by the crab thrusting its tail into an empty mollusc-shell. Upon this a baby Anemone settles, and the growth of the two partners keeps pace, but all the time the Anemone is gradually dissolving the lime out of the mollusc-shell, until at last nothing of it is left but the form of its exterior. The tiny Hermit has been forced by the inherited habit of its race so to protect itself; but, considering that in the depths where it spends its life shells are rare—the Mollusca being found chiefly in shallow water—it is a distinct advantage to it to have set up this constant partnership with the Anemone. Henceforth, when it casts its natural armour and simultaneously increases its bulk, it is saved from the worry and risk of searching far and wide for another shell that will accommodate its larger proportions. The

Anemone has been increasing by budding, and soon there is a connected colony of Anemones, whose gradual growth is always sufficient to cover the Hermit, and to obviate all necessity for any changes of residence. The Anemone benefits also in the same respect, for instead of the risk of being detached from one shell and being transferred to another, or waiting till another small Hermit takes possession of the vacated home, he has the same horse to draw him over the bottom so long as that horse lives. It is thus clear, as Alcock puts it, that this partnership between these two species has become "a *necessity* of existence for both."

Epizoanthus incrustatus, the Anemone we have mentioned as commonly accompanying the Downy Hermit, is not so exclusive in his choice of a partner. He has been found as a wrapping to several of the smaller Hermits, including *Catapagurus sharreri*, *Eupagurus politus* and *E. kröyeri*. There can be no question as to the popularity of these Hermits as messmates, for sometimes we find there is distinct competition for their friendship, a rivalry that at times may possibly be embarrassing to the Hermit. Thus we learn that *Catapagurus sharreri* sometimes has not only its coating of *Epizoanthus*

incrustatus, but over that a great-coat supplied by *Adamsia sociabilis*.

Other branches of the Hermit-crab family exhibit similar cravings for Anemone society, and not only in northern seas. During the cruises of the medical officers of the Indian Army in their aptly named vessel, the *Investigator*, a number of examples were brought to light. Thus *Parapagurus andersoni*, housed in shells of *Natica* and *Bathybembix*, were found invested by a Sea-Anemone; *Parapagurus minutus* in shells of *Dentalium* encrusted by a colony of Palythoa; *Parapagurus affinis* in shells of *Natica*, some of them invested by a Sea-Anemone; *Sympagurus monstrosus* in shells of *Rostellaria delicatula*, most of which carry an Anemone; *Paguristes puniceus* also in shells of *Rostellaria*, many of them encrusted by a colonial species of Anemone (*Zoanthus*); and a new species of *Paguristes* living in the shells of Murex, Rana, etc., many of which are invested by a Sea-Anemone besides being encrusted by a species of Acorn Barnacle (*Balanus*). These were obtained from various depths between 55 and 719 fathoms.

There are Hermits so keenly alive to the desire manifested by the Sea-Anemones to stand as their friends that they do not trouble to seek for a shell

in which to lodge; and several of the smaller species, such as the Hollow-handed Hermit (*Eupagurus sculptimanus*), are encased, with or without a molluscan shell, in a little sponge known as *Suberites ficus*. Some of these shell-disdaining species use their Anemone more as a mantle than as a house. There is Anderson's Hermit (*Chlænopagurus andersoni*), for example. It is a good-sized example, not much inferior to our Common Hermit, and is found in about 100 fathoms of water off the Malabar Coast. At that depth mollusc-shells large enough to house its mature growth are not to be found at every turn; but at no time of its life does it use a second-hand shell, but is wrapped up in an Anemone (*Mamillifera*) somewhat similar to Prideaux's Cloaklet (*Adamsia*). *Mamillifera*, however, instead of being a solitary Anemone, forms colonies of a soft, flexible character, and the blanket so constituted is held over the Hermit's back by tucking one end under its tail and hook-like swimmerets, and by grasping the other end in its pincer-claws. When such full protection is not required the sheet is allowed to lie loosely on the Hermit's hinder parts; but when the Hermit wishes to hide the legs are extended and the covering drawn forward over the Hermit's head. Captain

PLATE 29 HOLLOW-HANDED HERMIT IN SPONGE (*Suberites*). Page 100

The Sponge is alive and grows in such manner that it does not interfere with the Hermit's activities.

Photo by Author.

Anderson, its discoverer, says this operation is performed in a manner that is particularly neat. "The examination of a large series of specimens, in all stages of growth, shows that the partnership begins, at an early period of the life of both animals, by the settling of the parent-polyp of the colony on the telson [tail] of the little Hermit-crab. As the Hermit-crab grows, the investing-polyp increases in size, *pari passu*, by budding, so that in all stages of its existence the Hermit-crab has a cloak of suitable dimensions. On the other hand, the nutrition and growth of the polyps is assured by the fact that the agency of the crab changes them from sedentary to locomotive animals."

The habit of using a cast-off sea-snail's shell as a covering was, no doubt, adopted by the original Hermit-Crab, the founder of the family, in primitive times, and is thoroughly ingrained in all the branches of the family that can trace their origin back to him. We find that as soon as the Hermit has cast off its larval skins it seeks around for an empty shell small enough to accommodate its almost microscopical body. In many cases it must requisition one from a newly hatched mollusc. Mr. Gurney tells us that he found in the egg-capsule of the Common Whelk a whelk-shell not

larger than a No. 5 shot, already occupied by a little Hermit about an eighth of an inch long, and in another capsule a Hermit of similar size, but without a shell. No doubt he was there for the purpose of acquiring one.

Alcock points out that, in the Indian seas at least, the Hermits which are conspicuous among deep-sea animals as having their eyes normally developed, carry Anemones about with them, and the latter are frequently luminous to a high degree. It is, therefore, probable that they are enabled to use their eyes in the normal manner owing to the light they carry about with them. There is thus added one more to the wonders of these remarkable relationships.

But it is time we finished with the Hermits, though we have not exhausted the family. The Hermits are a numerous tribe, and it is probable that they all agree in this quality of business-like friendliness, though the social economy of some has not been made out owing to their habit of living at great depths. Let us take a glance at a few of their more finished relations.

We have already referred briefly to a remarkable crab found commonly in the Adriatic and the Mediterranean and obtained occasionally off our

own coasts, to which in lieu of a proper folk-name we have elsewhere given the name of the Gnome (*Dromia vulgaris*), suggested by his remarkable appearance when undisguised. In his usual resting position, with his limbs closely pressed to his body, he is almost spherical; and with the exception of the pink fingers of his pincer-claws, he is clothed with a dense pile of stiff hairs. His hindmost pair of legs are so pushed out of their normal position that at first sight they appear to be attached to the back. There is a special reason for this position, and to make it more effective they end in very delicate nippers like curved needle-points. The special object in view quite justifies the abnormality. The Gnome, though his scientific name, *Dromia*, signifies a runner, is one of the most lethargic and sedentary of our crabs, and so that in his stationary position he may not become too noticeable to enemies that may be passing that way, he will with these claws hold an empty bivalve shell over his back to cast a shadow over him and put him in the shade. But most frequently his umbrella consists of a large flat-growing sponge, into which he hooks his hinder pincers. And yet one would think that the male at least is sufficiently endowed with powerful nippers to withstand the

assaults of an enemy as well as half-grown specimens of the Jack Crab (*Cancer pagurus*) who ask the aid of no associate and adopt no disguise. As we write we have before us an example (a male) whose back measures three inches across either way. His pincer legs are five inches long and the heavy hand is three and a half inches in circumference. He was dredged in 15 fathoms of water in Gorey Roads, Jersey. Though he looks perfectly able to take care of himself, his back is covered almost entirely by the usual big sponge. We suppose that his sedentary habits make him liable to be taken by surprise unless he is disguised in this manner. In this case it does not appear that there is a proper mutual arrangement. Occasionally the sponge, at first held in position by the crab, may attach itself by new growth to the crab's shell, but as a rule it continues to be separate. In the case of a large female we possess there appears to be a real union between the sponge and the crab, but as we did not capture it, but received it in a dried condition, we have our doubts.

In connection with the Gnome, it is interesting to note how easily one may be misled by imperfect knowledge to an erroneous conclusion in these matters. Bell, who wrote an admirable work on

PLATE 30 GNOME CRAB COVERED WITH SPONGE. Page 104

The living Sponge is held in position by the two hinder pairs of legs of the Crab, which are modified for this purpose.

Photo by Author.

the "Stalk-eyed Crustacea" (1853) at a date when the subject of Commensalism had not been dreamt of even, tells how he had received specimens of this crab from Sicily "which had the carapace entirely covered with a sponge which had grown over it, concealing even the two hinder pairs of legs which were closely pressed against the back, and rendered immovable." It is evident that he considered the sponge as a parasite which had grown in spite of the poor oppressed crab, and that its weight had rendered certain limbs of the latter useless. A confusion of cause and effect.

An allied species, *Cryptodromia lateralis*, found in the seas that separate Australia and Japan, is almost invariably found covered by a sponge. Another species, *Cryptodromia pileifera*, found on the reefs of the Andaman Islands, is never found without its protective sponge—"each crab being completely concealed beneath a little tightly-fitting sponge shaped liked a cap."

Alcock's Hermits that carry luminous anemones have a parallel in a shore-crab, *Melia tesselata* of the Indian Ocean, which, according to Borrodaile, goes about ordinarily with an anemone held in each pair of pincers. The crab detaches them from their perch on the rock and carries them to a

good hunting-ground where the anemone catches food, but a portion at least is hooked out of the captor's mouth by one of the crab's first pair of walking legs. Whether this is the result of friendly arrangement, or a mere yielding to *force majeure* on the part of the anemone is not clear. We think the crab is quite smart enough to make a cat's-paw of the anemone; at the same time the honourable character of the arrangements between the Hermits and their messmate anemones disposes one to take the view that Melia and the anemones have an equitable understanding also. If we are to believe Mobius, who was the first to call attention to this strange business, when the crab is robbed of its anemone it appears to be greatly agitated, and hunts about on the sand to find it again; and if the anemone be cut up by a cruel experimenter, will gather up the pieces.

Our large Thornback Crab or Gabrick (*Maia squinado*), likewise known in Cornwall as Gran'fer Jenkin, when it gets itself a new suit of clothes by casting off the old cramping armour, is dissatisfied with its own brightness, and imagines itself the cynosure of all eyes. It straightway cuts short lengths of seaweed and fixes them across its back, and among them disposes bits of sponge, anemones

PLATE 31 CRAB (*Melia*) CARRYING ANEMONES. Page 106

The Anemones are detached from the rock and carried about to catch food.

By T. Carreras.

and other things, soon giving itself the old disreputable appearance again. Nature has obligingly fitted it up for easy disguise by covering its shell with spines, hooks and bristles, and it knows how to drag the weeds under the hooks so that they become fixed. Anemones, sea squirts and sponges, it deliberately detaches from the rocks and plants in the hollows between the greater elevations that terminate in stout spines, and these not only attach themselves but grow in the new situation. We have taken more than half a dozen small anemones (*Cylista viduata*) from the back of one medium-sized Maia. On the back of this crab, among the rubbish purposely fixed there, you may find many interesting and diverse forms of life. Among other things the small crustaceans known as Amphipods may be found there in variety, and one of them, called *Isæa montagui*, has been found nowhere else. Its structure is so remarkably adapted to a life in this position that there can be little doubt that its differentiation as a species is entirely due to its exclusive mode of life. These creatures are a necessity to the Maia as scavengers, for though it wishes its enemies to pass it by as a little heap of rubbish, it does not wish some of the constituents of the rubbish heap to go too far in the decomposing

direction. Some of the weeds being mere fragments do certainly decay, and it may be fairly presumed that the Amphipods and the sea-worms find food in nibbling at the decaying and therefore softened portions, which they consume and so prevent becoming a nuisance and possibly prejudicial to Maia's health. Some of the creatures so found on the back of this crab have settled there, no doubt, under the impression that it was a mere rubbish-coated stone, and are not to be considered as commensals; but the planted anemones and Isæa we certainly may regard as true messmates.

Several other of the Spider Crabs have this same trick of covering themselves with bits of weeds, zoophytes and sponges. Gibb's Spider Crab (*Pisa tribulus*) is frequently buried, so to speak, under a mass of living sponge bigger than itself, and not mechanically attached—though it may have been in the beginning of the partnership—but organically in contact all over the crab's back and not to be separated without tearing the sponge to pieces.

Cranch's Spider Crab (*Achæus cranchii*) also has its back covered with hooks, under which it catches pieces of the smaller seaweeds. We used to take this species among Sea Grass (*Zostera marina*) on the Cornish coast, and always found it so decorated.

The Scorpion Sea Spider (*Inachus dorsettensis*) was usually overgrown by a slimy yellow sponge that smelled very strongly, and was calculated to deter any fish from making a meal of the crab. The same may be said of the allied species *Inachus dorynchus* and *Inachus leptochirus*; also of the species of *Hyas*. It was formerly considered that these Spider Crabs owed their decorations to their sluggish habits, their long unmanageable limbs being supposed to impose inactivity upon them, and so render them powerless to elude the attachment of all kinds of rubbish, which a more active life would have enabled them to shake off. This view, we fear, was obtained by a study of cabinet specimens, or at least of dead specimens out of their element. Any one who had studied these crustaceans in an aquarium—in itself only a poor substitute for observation of the creature in nature—would have seen that on casting their old shells they deliberately set themselves to plastering the new coat with such material as may be available to them in the usually too tidy surroundings of the aquarium tank. As we have said, Nature has liberally provided them with hooks and spines upon which to hang and fix this tawdry finery. The living embellishments as a rule they cannot find

in such an environment, but they have been known to detach these from the old shell and transfer them to the new. They do not live on the bottom, burrow in the sand, or push themselves under stones, as crabs with shorter and stouter legs do. They live among the smaller seaweeds, where their long attenuated limbs enable them to climb like spiders; and here we have the clue to their disguisements. The ribbons of seaweed help them to fit in to their surroundings, but should this fail in the case of a particularly keen-eyed fish, then the presence of sponge or anemone may be considered as sufficient to make the enemy pause, and on second thoughts pass on. There can, we think, be no question as to the association being true commensalism. The cases where sponges, Alcyoniums, and anemones have been seen to be planted were probably instances of temporary disguises when their shell had been made dangerously clean by experimenting man. In a wild state they might plant "cuttings" to induce a natural growth; but where sponges are found to be in close and organic attachment all over the shell this must represent a development from the larval condition.

Pinnaxodes chilensis is said to be found *inside* the shell or "test" of the Sea Urchin, *Strongy-*

locentrotus gibbosus, occupying a chamber formed by the distention of part of the intestine. The position disposes one to regard it as a case of parasitism, though it has been put forward as one of commensalism. If the facts are correctly reported, the crustacean must make its way, while still in the larval condition, through the mouth of the Urchin.

Among the Crustaceans that have been described as commensals is *Hapalocarcinus marsupialis*, but it is more probably only a mutualist. The female settles upon living coral, and so prevents further growth of that particular area. But the coral grows around her, and she is soon imprisoned in a cage of coral branches. As water comes through the interstices, bringing small animals with it upon which she can feed, she thrives in her prison. Nothing is known of the habits of the male. Mutualists also are the little Amphipods of the genus *Hyperia* that shelter under the bells of the larger jelly-fishes. So, too, is the little Wandering Crab (*Planes minutus*) often found clinging to large marine turtles. Its habitat proper is among the floating seaweeds of the Sargasso Sea; and no doubt these specimens found on the turtles have got adrift from the weed and have accepted the chelonian as the best available substitute.

Certain terrestrial Crustaceans, allied to the Wood-louse, are commonly found in Ants'-nests as commensals, and one of them has never been found in any other situation. These we shall have to deal with in a later chapter in connection with the messmates and guests of ants generally.

Barnacles, which are degraded Crustaceans, are often mentioned as messmates because of their attachment to whales; but as these do not appear able to render any services to the Cetaceans and get their own living from the waters, they must be classed among the mutualists. Among these may be named *Coronula diadema* and *Tubicinella trachealis* which live embedded in the Whale's skin. *Xenobalanus globicipitis* has also been found in similar situations; and *Chelenobia* on Turtles.

Spiders, which are near allies of the Crustacea, do not appear to form any of these partnerships. Probably, their bloodthirsty instincts prevent any friendly arrangements. According to a famous nursery ballad, the spider did once attempt to persuade a fly to share his parlour, but his approaches not having been met in the proper spirit, the fly and the spider have never been on a friendly footing since. The Acarina, or Ticks and Mites, are generally considered to be mere parasites. It

PLATE 32 DOR BEETLE. Page 112

A species of Mite lives on the beetle's armour and keeps it clean.

Photo by J. J. Ward.

is almost certain, however, that among the Mites there are exceptional species which have relations of another kind with their hosts. Particular Mites are invariably found on certain species of beetles and slugs, and although the authorities have labelled these indiscriminately as parasites, we have for many years regarded them as commensals.

On summer evenings in country lanes one will often be struck by the Dor-beetle (*Geotrupes stercorarius*) which, owing to the violence of the impact, falls to the ground and lies in a helpless condition on his very convex back. If we pick him up we shall find that his underside swarms with active little Mites (*Gamasus coleoptratorum*), of a yellowish-fawn colour. They run about over the polished armour-plates of the beetle, and cluster between the basal joints of his legs, where fringes of long hair afford them secure hold. Now, if it be considered that beetles of this family have no soft parts exposed, and that even the joints and articulations of their limbs are of tough material, it will be seen that there is little prospect of support for a crowd of tender creatures like Mites upon the Dor-beetle's crust. But if it be remembered that this beetle is largely occupied in mani-

pulating and digging under horse and cow manure, a reason for the presence of the Mites is manifest. They are there, not as parasites, but as messmates. When the beetle is busy digging they, no doubt, escape crushing by crowding about the base of his limbs, but afterwards they distribute themselves over his body and clean it from the odorous particles which cling to it, and which serve them for food. So invariable are these Mites as companions of the beetle that their presence has earned for him the name of Lousy Watchman, by which he is known in many districts. Another group of beetles, of which *Aphodius fossor* is a familiar representative, can mostly be found in plenty under a patch of cow-dung. The Aphodii are also accompanied by these Mites, as are the Sexton-beetles (*Silpha*). Similar Mites are found on the large Dung-beetles of the Tropics. Now, if Gamasus got its living, as is generally supposed, by sucking the juices of its host, one would expect to find it on beetles generally, without regard for their habits, whereas we find it only upon those that grub about in unpleasant substances which soil their hard exteriors, and which need the presence of a valet to keep them in a spruce condition. It is more than probable that the Mites find all the

PLATE 33 THE DOR BEETLE'S MITE. Page 114

A greatly enlarged representation of this commensal mite.

Photo by J. J. Ward.

food they require in what they clean off their host and messmate.

A parallel case of supposed parasitism which we believe to be really commensalism is afforded by the land slugs and some of the snails. The Great Grey Slug (*Limax maximus*) is a good example for observation, as it is scarcely ever free from attendant mites. Under the mantle or shield which more or less covers the back of the slug when in the contracted resting state, there is a chamber lined with blood-vessels, and at the edge of the mantle on its right-hand side there is an opening to the exterior which will be seen to gape and close at frequent intervals. This chamber serves the slug as a lung, in which the blood absorbs oxygen from the air admitted through the opening. A number of mites live in this chamber, whence they wander all over the upper surface of the slug. If these mites are mentioned at all in books on the Mollusca they are vaguely referred to as parasites. It would be of interest if one of the slug-specialists would investigate the relations of this mite to the slug, and tell us about them. We feel convinced as a result of our own meagre observations that they are not parasites but messmates. If they were parasites they would probably restrict themselves

to the pulmonary chamber, or would become more or less fixed on definite areas of the exterior, instead of running actively all over it. We believe they will be found to play the part of scavengers, ridding the chamber of particles of foreign matter that comes in with the air, but which the mollusc obviously has no means of getting rid for itself. The slug gives no sign that he is inconvenienced by the activities of these messmates—nor, indeed, that he is conscious of their presence, though the lining of the chamber must be of an exceedingly delicate character to permit of the interchange of oxygen and carbon through its tissues.

VII

SOME "WORMS" AND THEIR FRIENDS

VII

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The old zoological class Vermes was as useful in its way as the appointment of a Royal Commission still is, for the shelving of awkward questions not yet ripe for settlement. Any fairly low form of life whose natural affinities could not be made out immediately was dubbed a worm; and so the Class came in time to be like a lumber-room in which was a miscellaneous collection of odds and ends, waiting for some patient individual to come along who would dust them and sort them out into some kind of order. From time to time such individuals have appeared and have turned over the lumber, finding as they have flicked off the dust here or scraped the varnish there, that they have got hold of something that should have a place in the drawing-room or the library. Several of the "worms" we have to mention are creatures that have been in recent years removed from the

old position and put into higher places—some have been thought to be very near if not quite in the line of descent by which the aristocracy of the animal world, the Vertebrates, have come to their present high estate.

Among these are some of the creatures of which mention is made below, as it is still convenient in certain cases to consider them among their old associates for want of definite familiar names under which to describe them. One of these is *Phoronis*, formerly considered as a Gephyrean worm, which lives in a self-constructed tube, like some of the Hydrozoa. *Phoronis australis*, the largest species known, has been described by Haswell as occurring in communities of twenty to thirty individuals. They are from three to five inches long, and the colonies are formed in spaces in the substance of the tube inhabited and formed by a species of *Cerianthus*—one of the Sea-Anemones. Each worm has its own tube, very delicate and transparent, made up of several layers of material, the mouth opening on the outer surface of the tube of Cerianthus. A living Cerianthus occupies the larger tube and a community of Phoronis lives in the wall, their tubes interlacing with that of Cerianthus. This particular species of Phoronis never lives anywhere

else; whilst this species of Cerianthus is very rarely found unaccompanied by the Phoronis.

We have already mentioned several species of worms of other groups, such as the Polychæte *Nereis*, that is partner with the Common Hermit Crab, and the Gephyrean worm, *Aspidosiphon*, that lives with the Coral *Heteropsammia.* There are two or three other Polychætes that deserve a note. Two of these—*Acholoë astericola* and *Ophiodromus flexuosus*—live in the grooves that run from the mouth to the tips of the arms of the Butthorn (*Astropecten irregularis*), one of the Starfishes. Another—*Siphonostoma*—is found in the strange nests that are made by the File-shell (*Lima*). The worm belongs to a family whose members build themselves tubes out of grains of sand cemented together, but Siphonostoma has learned that he can save himself this trouble by coiling among the miscellaneous materials of which Lima's nest is constructed. A large worm, *Eunice philocorallia*—something like the Hermit's *Nereis*—is found in constant association with the Tufted Coral (*Lophohelia prolifera*), among whose branches the worm twines its tube.

Several worms of the genus Polynoë—mail-clad worms with two rows of overlapping plates covering

the back—have struck up messing arrangements with other worms. Thus *Polynoë johnstoni* is only found in the tubes of the Sandbinder (*Terebella nebulosa*). This is a case of very close intimacy, for there appears at sight to be room for only one occupant. *Polynoë marphysæ* in the same way shares the tube of the Eunicid worm, *Marphysa sanguinea.* Two other species live in the tube of *Chætopterus. Polynoë extenuata* finds lodging in the porcelain tubes of *Serpula vermicularis*; while *Polynoë arenicolæ* clings to the body of the Lugworm (*Arenicola piscatorum*), and in order that it shall not be seen has adapted its own colour to that of its host. *Myzostoma glabrum* establishes itself upon the disc of the beautiful Feather-star (*Antedon rosaceus*). It was first observed many years ago by J. Vaughan Thompson, who alludes to it as "a nondescript parasite" and "a complete zoological puzzle." He says: "It resembles a flat scale, and runs about with considerable velocity on the arms of the animal, and occasionally protrudes a flexible tubular proboscis, ending in a papillary margin." This Myzostoma has not been found elsewhere.

The underside of the wonderful "worm" known as the Sea-Mouse (*Aphrodita*) harbours one of the

Polyzoa. Several other marine worms, as we have seen, have commensal arrangements with small corals, which they carry about to fresh feeding-waters. The Polyzoa are social animals that form colonies of many individuals, all of whom have originated as buds from the original founder of the colony. This budding and colonial habit is all but universal throughout the class. But there is one genus, *Loxosoma*, in which alone the massing habit is abandoned. It is not unfair to suggest that *Loxosoma* has given up the family trait, because it has entered into commensal relations with certain worms, sponges and ascidians. *Loxosoma phascolosomatum*, of the Channel Islands, has never been found except attached to the tail of a Gephyrean worm named *Phascolosoma* in the mud of Grass-wrack beds. Other species are found on sponges. *Loxosoma annelidicola* has a stalk and attachment disc by means of which it adheres to a Polychæt worm that lives in a tube. The stalk bends to allow Loxosoma to lie on its back, and so escape injury as the worm rushes backwards and forwards in its tube.

VIII

PLANTS AND INSECTS—ESPECIALLY ANTS

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The ancients noted and remarked upon a number of the remarkable partnerships that exist between unrelated animals; and they knew the ant to be possessed of much wisdom, and its ways worthy of study by man. But if they had known of present-day revelations respecting the relations that these sagacious insects have with many plants they would have been justified in their belief in the Dryads—spirits that were imprisoned in trees, that were injured when the tree was injured and that died when the tree died. Modern thought denies consciousness to plants, though Huxley was bold enough to say that every plant is an animal enclosed in a wooden box; and science has demonstrated that there is no distinction between the protoplasm of animals and plants, and that if we get down to the very simplest forms in which

life manifests itself we can call them animals or plants indifferently. The higher forms of plant life with highly specialized flowers show that they are at least influenced by the insects that visit them. The production of acrid juices in their foliage, the transformation of shoots and other organs into spines and prickles has direct relation to the attack of browsing animals; the secretion of resins and gums by trees is a security against the entrance of fungus enemies to their tissues by way of wounds. There are many cases which may be cited as evidence of plants taking precautions to keep Ants (honey-stealers) out of their flowers; there are as many showing that they encourage Ants on their stems, in the character of police, in order that leaf-eating caterpillars may be kept away. But what is to be said when a plant supplies ready-made nests for the ants by a modification of its own structure, in order to be sure that the ants will live with them and protect them from various enemies.

Take the case of the Cow-horn Orchid (*Schomburgkia tibicinis*), which grows on trees in Honduras. Like most other epiphytal orchids (as those are called which grow on tree trunks or branches), it produces pseudo-bulbs, in which all its vitality can be packed to save it during the hot dry season,

PLATE 34. PSEUDOBULBS OF COW-HORN ORCHID WITH ANT-HOLES. Page 128

These pseudobulbs have hollow centres which protecting Ants fit up as nests.

Photo by S. L. Bastin.

when otherwise any plant that has not roots in the soil must perish. In this case the pseudo-bulbs are hollow, with a smooth lining, and are a foot or two feet in length. The great length is of course necessary to provide storage room in the walls, on account of the centre being hollow. At the base of the pseudo-bulb there is *always a small opening*, and ants enter thereby and fill the empty space with their nest-material and arrange it in tiers of cells and galleries from top to bottom. Here in the wettest of wet seasons they are perfectly dry. If any enemy appears calculated to do injury to the plant they issue forth in a swarm and attack him. They have the best of reasons for doing so; the plant is *their* plant, and the safety of their home and their offspring is involved. A similar provision is made by *Diacrium bicornutum*, another epiphytal orchid of South American forests.

These orchids suffer much from the attacks of insects, particularly from cockroaches, if they are not so guarded. They get all their nutriment from the air, sending down long aerial roots that gather moisture, and when they run down the trunk organic matter also. These aerial roots end in a growing point, half an inch long, which is a particularly tempting bit for the cockroach, but if it

is destroyed the further growth of that root is stopped. To prevent this the species of orchid known as *Coryanthes* provides quite a distinct barrack for an ant garrison. Hear Mr. James Rodway, who has spent years in the Guiana forest, and knows well-nigh all its secrets : " Instead of a hollow pseudo-bulb, the Coryanthes provides an oval mass of fibrous roots as distinct from those so well known in the other orchids as their object is different. In the Coryanthes the ants establish themselves, filling up the interstices to make a waterproof nest, whence they are ready to issue on the least alarm of an enemy. Being carnivorous they can do the plant no harm, but on the contrary are so useful that without them it suffers greatly from cockroaches and other pests. This is easily proved by specimens brought to our gardens, where, on account of the collectors having removed their useful tenants by soaking them in water, they are particularly subject to the attacks of insects and rarely thrive for any length of time. The nearly-allied *Gongoras* also make a less perfect provision for ants, and the great *Oncidium altissimum* often has such large communities that the collector finds it very difficult to dislodge the plant from its perch without getting severely bitten."

Consider these cases and what they indicate. It is generally admitted that the Ant has intelligence, even though he be a mere invertebrate; and therefore there is nothing very remarkable in his taking advantage of conditions that suit his purposes. The trouble comes with the plant. How shall a thing that has no reasoning power, no sense, be brought to develop its roots and pseudo-bulbs in such a manner that they will attract and be useful to the one type of insect life that can be of assistance to the plant as guardians? Such an arrangement in human affairs would be regarded as a piece of cunning diplomacy. We may suppose that in the first case the hollowness of the pseudo-bulb was due to arrested development or to the attack of some insect enemy, but, the cavity being appropriated by the ants to the advantage of the plant, there was a tendency on the part of later seedlings to reproduce the abnormal condition which ultimately became so normal that the children of that region make use of these hollow pseudo-bulbs as musical instruments, and the plant has got the name of Cow-horn Orchid.

Somewhat similar to the provision made by *Diacrium* and *Schomburgkia* for ant-messmates is the hospitable arrangement of an unrelated plant

in another part of the world. In the islands and archipelagos of the southern hemisphere there are found about twenty species of a genus of Rubiaceæ, known as Ant-nest plants (*Myrmecodia*). Like the orchids just mentioned, they are epiphytes, growing on the branches of trees, and like these they have developed the equivalent of a pseudo-bulb to tide them over the dry season. In this case it is an enlargement of the lower part of the stem into a turnip-like swelling which develops ridges and spines on the exterior to keep off the attacks of arboreal mammals. These plants " go one better " than *Diacrium*, for instead of merely offering the ants what builders term a carcase, to be fitted up with internal divisions to suit the requirements of the tenant, *Myrmecodia* has utilized the central parts of its pseudo-bulb for storage purposes, but left innumerable chambers and connecting galleries, so that the ant has merely to occupy them and carry in its own supplies.

Prof. Moseley, who accompanied the *Challenger* expedition, and saw these plants at Amboina, says the swollen base both in *Myrmecodia* and the allied *Hydnophytum* is caused by the ants themselves. He says: " As soon as the young plants develop a stem, the ants gnaw at its base, and the irritation

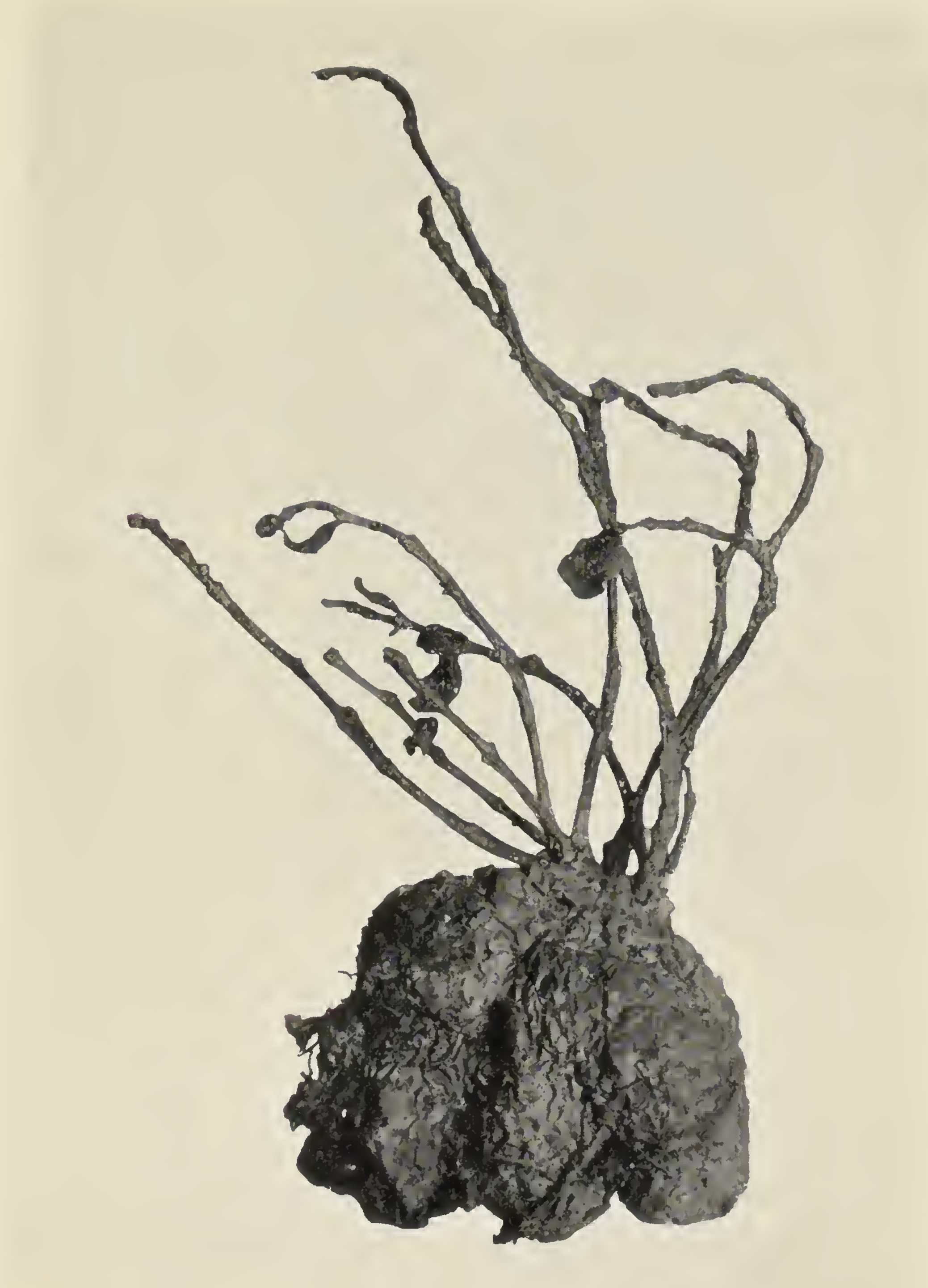


PLATE 35 MYRMECODIA, USED AS ANTS' NEST. Page 132

The interior is divided into cells and galleries which Ants utilize as nests.

Photo by S. L. Bastin.

produced causes the stem to swell ; the ants continuing to irritate and excavate the swelling, it assumes a globular form, and may become larger than a man's head. The globular mass contains within a labyrinth of chambers and passages, which are occupied by the ants as their nest. The walls of these chambers, and the whole mass of the inflated stem, retain their vitality and thrive, continuing to increase in size with growth. It appears that this curious gall-like tumour on the stem has become a normal condition of the plants, which cannot thrive without the ants. In *Myrmecodia armata* the globular mass is covered with spine-like excrescences. The trees I referred to at Amboina had these curious spine-covered masses perched in every fork, and with them also the smooth-surfaced masses of a species of *Hydnophytum*."

It will be noted that Moseley was of opinion that the production of the swelling is due to irritation set up by the gnawing of the ants ; but this does not agree with the experience of H. O. Forbes, who actually grew the plants from seeds, completely isolating them from contact by ants. His seedlings grew vigorously and developed the tuberous growths with their internal branching cells and galleries *from the very first.* However caused in the pro-

genitors of the species, to-day the production of these pseudo-bulbs has become normal and hereditary. At first these masses are filled with a delicate pith and in the centre is a chamber filled with a watery liquid. The pith contracts and leaves winding passages which are found out by the ants, who are at first attracted by this pith and liquid. These constitute the plants' invitation to the ants to make their home there. The kind of ant is always the same—*Iridiomyrmex myrmecodiæ*—a minute species whose sting is of the most virulent character, out of all proportion to its size.

No plant, of course, would act thus from motives of pure philanthropy. There must be a proper business principle underlying any such action; and this is found in the protection these fierce little ants provide against other insects who would, if allowed, despoil the plant of its necessary leaves.

But even this does not represent the highest and most complicated instance of the plant's sagacity. The plants that have developed their leaves into pitchers are tolerably well known; how by growing in poor swampy soil they have been forced to resort to this method of obtaining proteid material by trapping insects, digesting them and assimilating

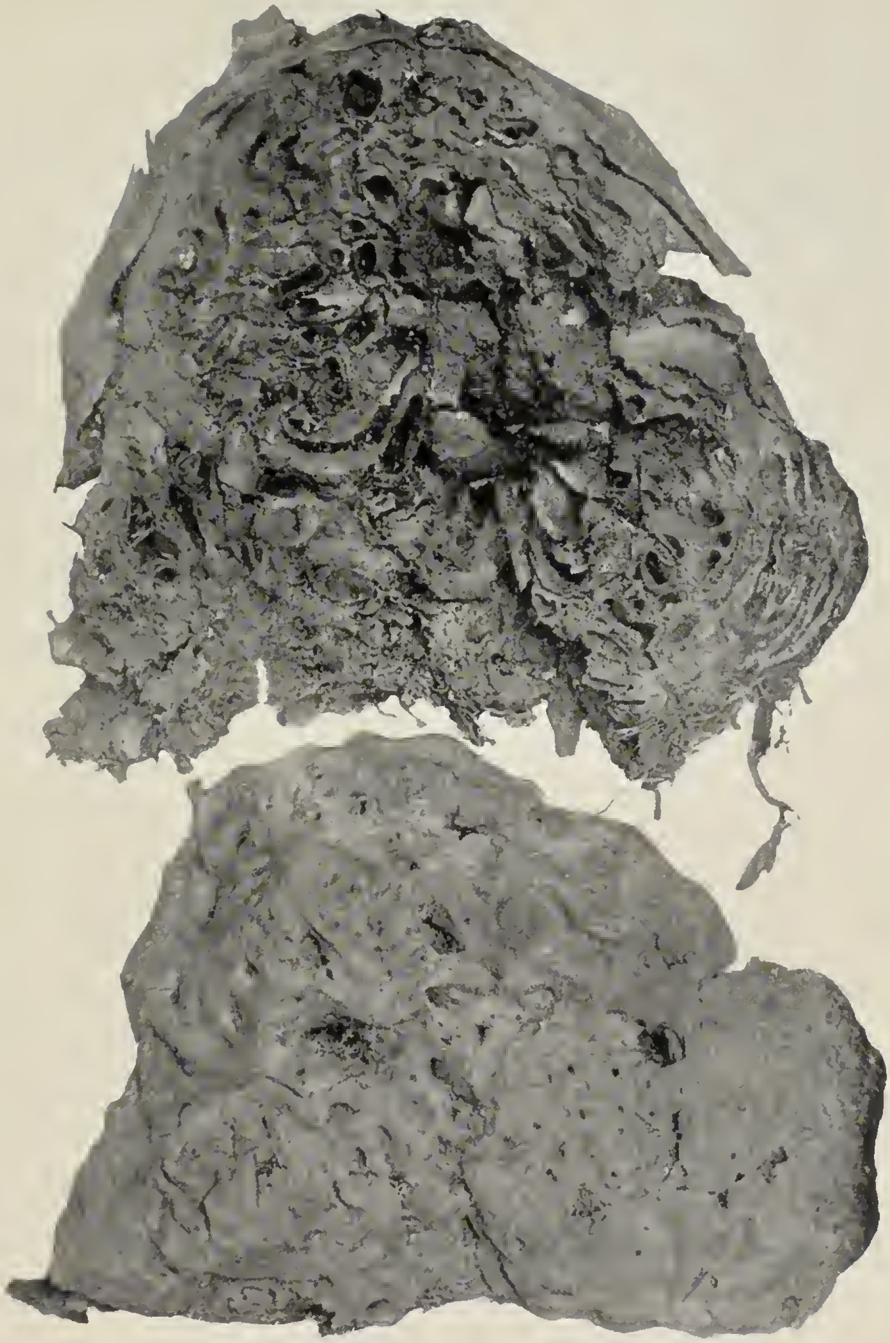


PLATE 36 HYDNOPHYTUM. Page 134

The lower photo shows the exterior, the upper the interior with the Ant galleries.

Photo by S. L. Bastin.

the results. In several species of *Dischidia* from the East Indies there is a remarkable development of the leaf to form not only a pitcher, but two pitchers, one inside the other. These remarkable plants—epiphytes again, though belonging to a quite distinct family, the Asclepiads—and their pitchers have long been known, but little was known of their use until Mr. H. W. Pearson a few years ago made a thorough examination of them, which enabled him to offer an explanation of their peculiarities. Like the other pitcher-producing plants, *Dischidia* has suffered from the difficulty of obtaining certain food-elements in the situations it has selected, or been driven into in the struggle for existence. But the chief factor that has led to the evolution of these pitchers appears to be a desire to conserve its limited water supply. Not all the species of Dischidia develop them, but those that do are what are known as Xerophytes—that is plants growing in dry situations. The stomata or breathing pores of the leaf are on the inner surface of the outer pitcher, and the moisture given off in transpiration becomes condensed and is available for further use. But how can the plant recover it? From the base of the short leaf-stalk a delicate system of roots enters the outer pitcher and ramifies

among *the soil which it contains also.* How does this soil get into a pitcher far above the ground, and yet be of the same character as the soil at the foot of the tree upon which *Dischidia* is growing? The answer is—ants.

The inner pitcher secretes from its tissues a substance very similar to grape-sugar in its composition and sweetness. This is a bait, for ants have "a sweet tooth." They enter for the sake of the sweets. They appear to reason that where such things are to be found, and lodgings are already provided, it is advisable to establish a home. So they carry up soil from the base of the tree and fill up the outer pitcher with cells and chambers after the approved ant-fashion. Ants die like other creatures, and their dead bodies and excrement help to enrich this soil, to the advantage of the plant. The moisture emanations from the stomata are conserved by absorption by the soil, from which in turn the rootlets are enabled to suck it up. Not only so, but in the soil has been found the mycelium of a fungus which bears a strong likeness to that grown by the South American ants (*Atta*) in their fungus gardens. The soil is never taken into the inner pitcher, nor has the fungus mycelium been found there.

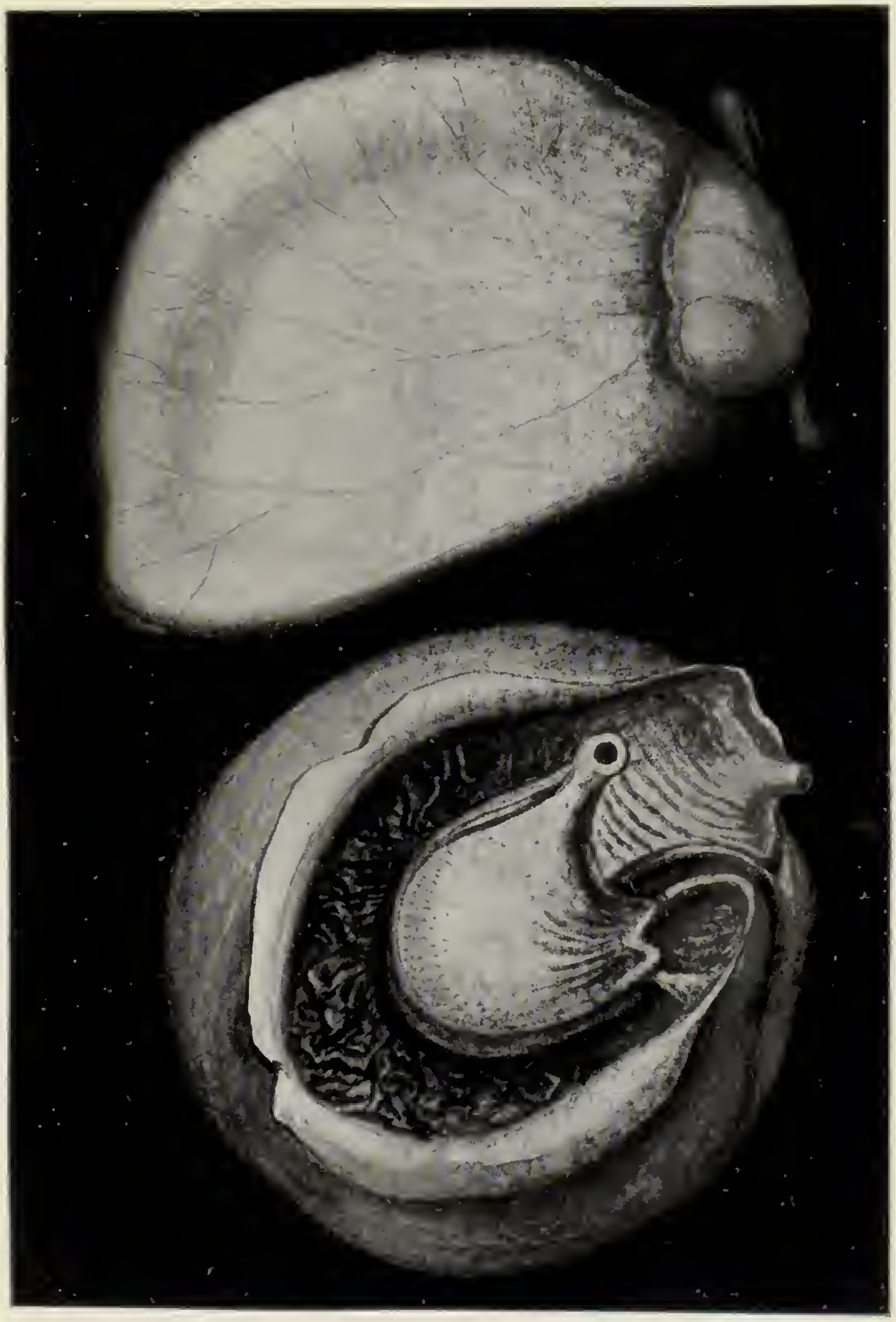


PLATE 37 PITCHERS OF DISCHIDIA. Page 136

The lower example is laid open from the side to show the inner pitcher.

By T. Carreras.

If search is made among our native plants and trees, many evidences will be found of the desire to encourage ants on their leaves and branches. These mostly take the form of glands upon the leaf-stalk, and these glands either secrete a sweet fluid or are themselves sweet, and are respectively licked or nibbled by the ants. Such glands may be found, for example, on the Cherry, Vetch, and many other plants. Similar glands occur on the bud-scales of Hevea, one of the rubber-producing plants, and at the base of each expanded leaf. The Acacias have these sugar-secreting glands on their leaf-stalks, and, in addition, at the tip of the leaflets some produce special little expansions which contain albuminous material, also for the ants. This does not comprehend all their care to ingratiate the ant and ensure his presence in policing their stems and foliage. At the base of the leaf-stalk many plants bear a pair of stipules which have served as wrappers for the unexpanded leaf whilst it was in the leaf-bud. On these stipules in the Vetch (*Vicia sativa*) and the Broad Bean (*Vicia faba*) there is a dark patch from which a sweet sticky fluid exudes. If either plant be watched for a few minutes a brown ant will be seen to climb up the stem and go to the stipule, where it licks

up the sweet excretion. In the case of the Vetch and some other plants the ant renders service in return for the plant's provision of refreshment, by clearing it of insects that would cut the leaves. In the case of the Bean it is doubtful whether the ant's attentions work out altogether to the advantage of the plant. We suspect that a deficit would be shown on the Bean's profit and loss account; for though the ant may destroy young caterpillars when visiting the nectar glands she is also beneficially interested in the swarms of black aphides that invest the Bean-stems, and which are probably planted on the young Bean plant by the ants. In various species of Acacia these stipules have been developed into a pair of stout thorns to protect the plant primarily from the teeth of browsing mammals, whose muzzles get pricked by the spines if they venture too near. These thorns arise in pairs from the stems; and in some Tropical American species a pair presents the appearance in miniature of the horns of cattle.

Belt, in his *Naturalist in Nicaragua*, tells us that in the young state these thorns are filled with a sweet pulp, and that a little ant (*Pseudomyrma bicolor*) has by some means discovered the fact. It, therefore, systematically bores a hole near the

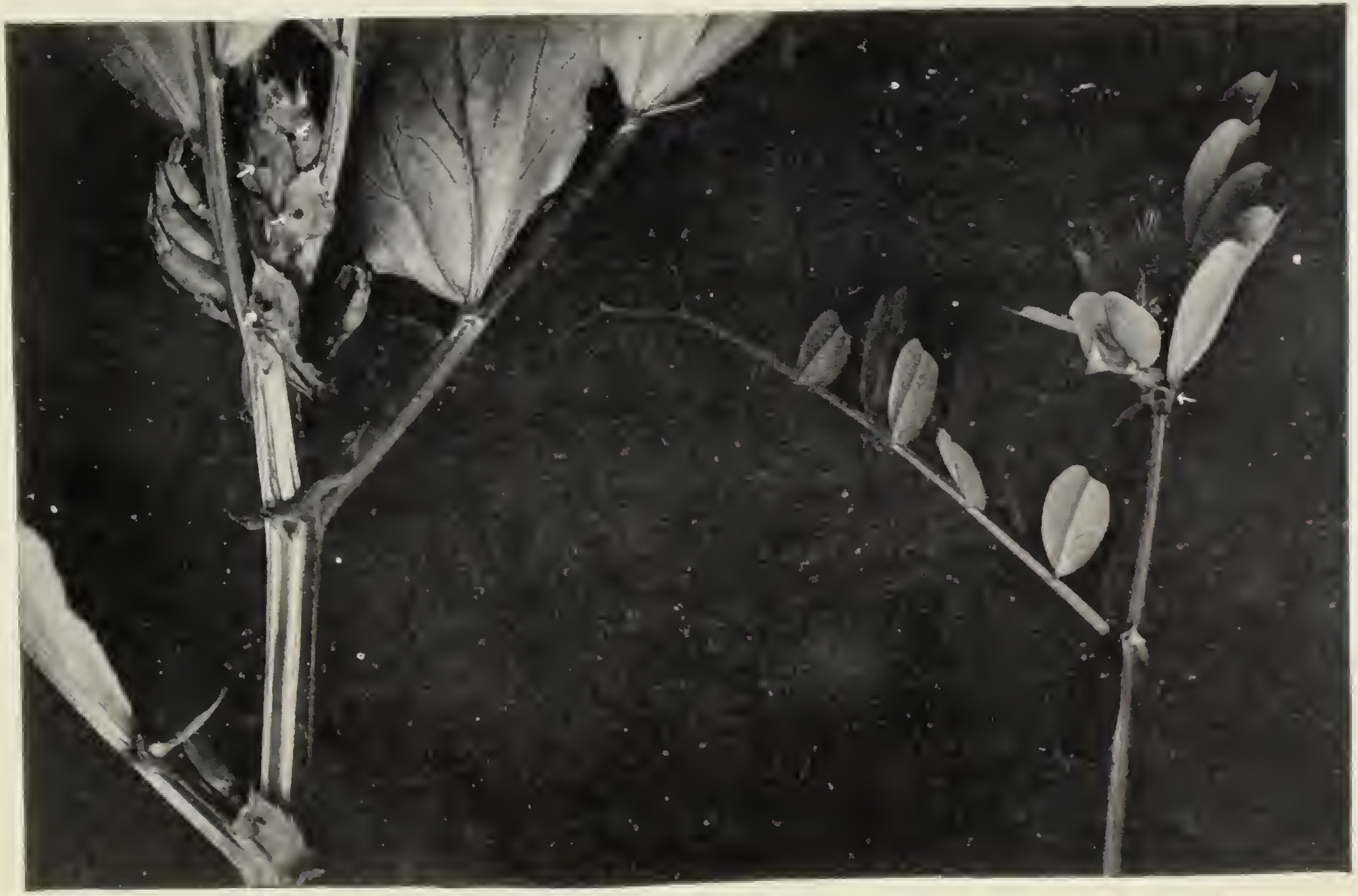


PLATE 38 NECTAR GLANDS OF BROAD BEAN AND VETCH. Page 138

The white arrows point to the dark glands from which the nectar exudes.

Photo by Author.

top of one of the thorns of the Bull's-horn Acacia (*Acacia sphærocephala*) and eats out all the pulp, leaving the walls to harden into a strong spine. The interior is then utilized by the ants as a nest, whence they issue to protect the foliage from the depredations of other insects, snails and even the mammals that are leaf-eaters. Then, in order to retain the services of this body of ant-police—the food in the thorns having been exhausted—the plant supplies other food in the form of nectar from glands on the leaves, and some of a more solid character which we shall mention presently. The chief enemy these ants have to keep off is the large Sauba or Leaf-cutting Ant, which is for ever engaged in stripping trees and bushes of their leaves and carrying these home in pieces larger than itself in order to convert them into leaf-mould for making into mushroom-beds!

It is remarkable evidence of the economy of labour these ants practise and the caution they display to ensure privacy, that they do not make a hole in each thorn of a pair. They enter and clear out one thorn to its base and then eat through the wall that separates the two, and clear out the second also; and so the one entrance serves for the two thorns. In these secure retreats their

young are reared, and in the wet season out on the Savannah, when the Acacia leaves are new and tender, every thorn is tenanted by these ants. "Hundreds of ants are to be seen running about, especially over the young leaves. If one of these be touched, or a branch shaken, the little ants swarm out from the hollow thorns, and attack the aggressor with jaws or sting. They sting severely, raising a little white lump that does not disappear in less than twenty-four hours." Belt, from whom we have quoted, goes on to describe the wonderful way in which the plant has laid itself out to encourage and reward these ants—that is, to make it worth while for this particular species to inhabit the plant and protect it from the leaf-cutters—arrangements that are not without a suggestion of cunning and calculation on the part of the plant. The reward takes the form of "creature comforts"—not merely the food stored at the beginning in the bull-horns, but two other varieties of food provided not all at once, but in doles spread over a long period, with the evident purpose of retaining the services of the ant continuously.

"To secure their attendance at the right time and place, this food is so arranged and distributed as to effect that object with wonderful perfection.

PLATE 39 BULL'S-HORN ACACIA. Page 140

The thorns are hollow and are utilized by Ants as nesting-places.

Photo by Harold Bastin.

The leaves are bi-pinnate. At the base of each pair of leaflets, on the mid-rib, is a crater-formed gland, which, when the leaves are young, secretes a honey-like liquid. Of this the ants are very fond; and they are constantly running about from one gland to another to sip up the honey as it is secreted. But this is not all; there is a still more wonderful provision of more solid food. At the end of each of the small divisions of the compound leaflet there is, when the leaf first unfolds, a little yellow fruit-like body united by a point at its base to the end of the pinnule. Examined through a microscope this little appendage looks like a golden pear. When the leaf first unfolds, the little pears are not quite ripe, and the ants are continually employed going from one to another, examining them. When an ant finds one sufficiently advanced, it bites the small point of attachment; then bending down the fruit-like body, it breaks it off and bears it away in triumph to the nest. All the fruit-like bodies do not ripen at once, but successively, so that the Ants are kept about the young leaf for some time after it unfolds."

It seems clear that the presence of the Ants is essential to the proper development of the thorns, for in plants grown by Belt in the forest where the

Pseudomyrma do not come, the thorns turned yellow and dried up into dead but persistent prickles. But Rettig, it should be added, is of opinion that Belt's belief that enlargement was caused by the ants was due to insufficient observation: it is not due to the ants, though the enlargement does not occur till the plant has grown considerably.

Another species of Ant, a small black one named *Cremastogaster*, is also found at times taking entire possession of the Acacia; and it makes its entrance at the base of the pair of thorns.

Another species of Acacia (*A. fistulosa*) is a native of Africa, and has the base of its spines greatly inflated. At first they are white, later becoming brown or black. They are nearly always inhabited by a species of *Cremastogaster*, either *C. chiarinii*, *C. ruspolii* or *C. acaciæ*. Keller says that this Acacia is never eaten by cattle, and he attributes its immunity to the protection afforded by the presence of the Ants. He says the inflations are "produced in great numbers at the beginning of the rainy season, when the vegetation awakens, and are then green and soft. I never saw a hole in one of them [at this stage]. They are completely closed on all sides, and it is not till later

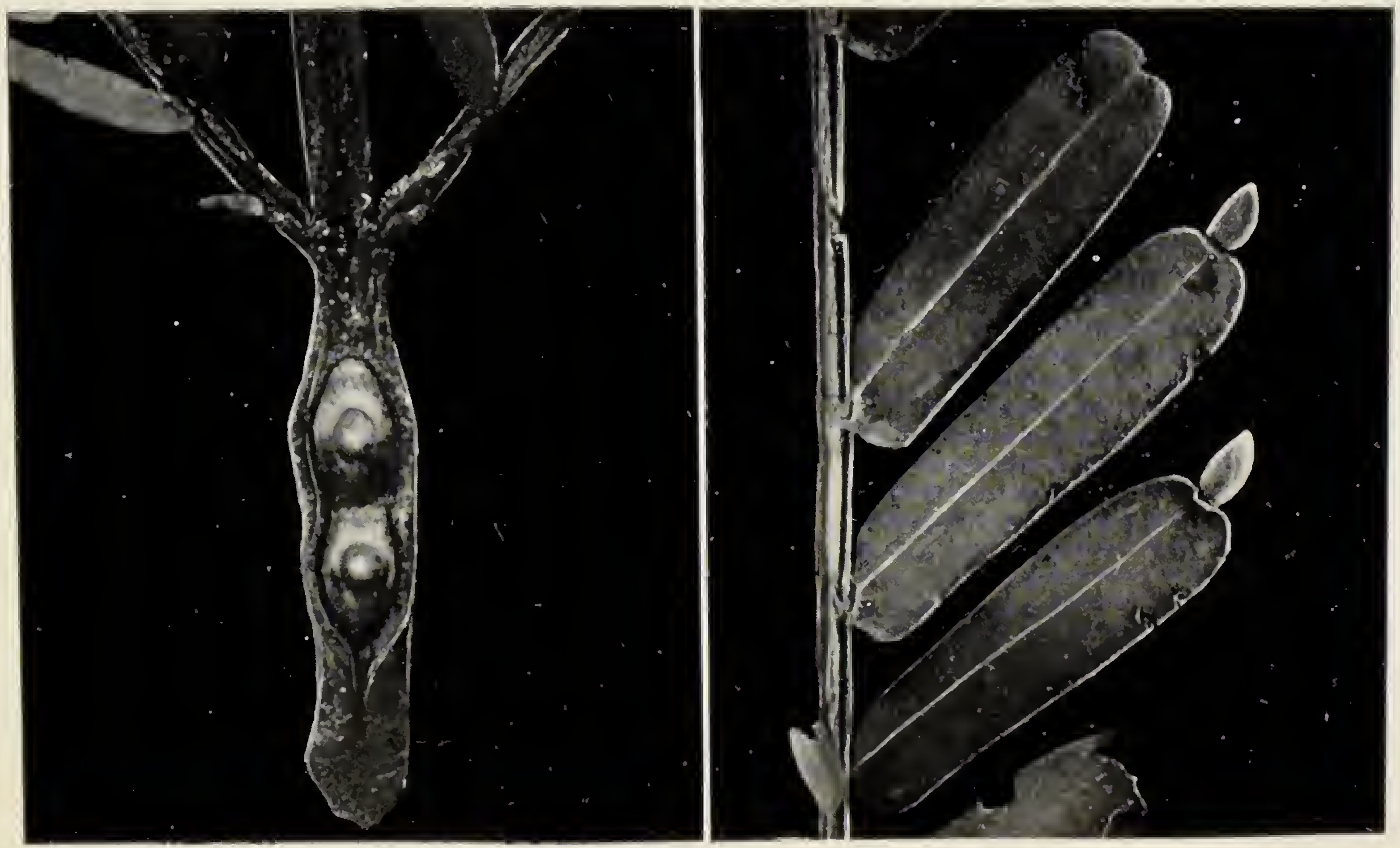


PLATE 40 — BULL'S-HORN ACACIA. — Page 142

The first photo shows two of the nectar-glands which provide refreshment for the Ants. The second shows two of the remarkable "Belt's bodies."

Photos by Harold Bastin.

that they are opened by the Ants. . . . The only explanation I can suggest is that in this plant an originally abnormal growth has become perfectly normal, under the influence of natural selection, through adaptation to symbiosis with Ants."

The South American tree known as the Imba-úba (*Cecropia*) has a hollow centre to its trunk, at first filled with pith, but later with only a few transverse divisions, and a small opening to the exterior, which is quite large enough for ants to use as entrance and exit. These openings are, of course, made by the Ants, but the tree gives them a hint where they can be made most easily by developing a little pit in the internode. A similar pit is found on Clerodendron stems which are also turned to account by the ant *Colobopsis clerodendri*. There are, indeed, a host of plants with these preformed cavities, both in the Old World and the New, that are utilized by the ants as nesting cavities; among them may be mentioned Bamboo, Kibara, Myristica, Randia, Tachigalia, Humboldtia, Tachia, Cordia, Pterocladon, Pterocarpon, and Bombax. It would be tedious to give the details of all these in their relations to ant-messmates: a few instances will serve as samples. Let us take the Imba-úba to begin with. On the lower Amazon the ants

(*Azteca muelleri*) have discovered what roomy interiors the tree possesses, and have found by the experience of innumerable generations what an admirable weather-proof formicarium each provides. Nearer the Andes they are taken possession of by bees. Whether the bees have ousted the ants or vice versa does not appear. Perhaps they have agreed upon each nation of Hymenoptera having its own "sphere of influence." Anyway, on the Amazon the ants will be found to have installed themselves in the hollow stems, and the moment the Cecropia's dread foe, the leaf-cutting Sauba, approaches the little ants pour out in force and stop the proposed depredations by putting their much larger relatives to flight. If the Saubas should by any means catch the guardian ants napping, they make good use of their opportunity for stripping the tree of its foliage. Belt tells how, on one occasion, during a spell of unusual cold, the ant-police had been benumbed and rendered inactive. Not so the stronger Saubas, who swarmed over the trees and stripped them. This, of course, only serves to emphasize the dire necessity to certain trees for entering into an alliance with carnivorous or stinging ants. Owners of coffee, cocoa and orange plantations sometimes suffer

PLATE 41 IMBA-ÚBA STEM. Page 144

The hollow stem of the plant is divided by transverse partitions. A small opening admits the Ants, who nest within and protect the tree from the leaf-cutting Saubas.

Photo by S. L. Bastin.

severely from the depredations of the Saubas; and some enlightened cultivators have learned how non-vegetarian ants are to be encouraged in order to keep down insect pests of various kinds. Thus, we are told that Chinese orange-growers collect ants' nests and put them on or at the base of their fruit-trees, and connect the trees by means of bamboo bridges, that the ants may pass freely from one to another in the performance of their police duty. Some Italian fruit-growers have found it advantageous to adopt a similar plan. But these trees that we have mentioned could have taught man the lesson ages ago. Forel, the Swiss entomologist, estimates that during their season of chief activity, 100,000 insects per day are required to maintain the numerous population of a single ants' nest. Such figures help one to realize the strictly business nature of the alliance between ants and plants. In the case of the Imba-úba, the plant does not add to its offer of lodgings the provision of food. To meet this want the ants keep Scale-insects, which secrete a sweet fluid, much as the aphis does for its ant-protectors.

Somewhat similar to the cases of Myrmecodia and Hydnophytum are those of two species of Polypodiaceous ferns (*Lecanopteris*) found growing

on trees in the same regions. Like our common Polypody (*Polypodium vulgare*) that grows in tree-forks and hedgerows in this country, these Malayan ferns have thick, fleshy creeping stems or rhizomes. In these species the stems have long winding hollow spaces which the ants have discovered. They obtain access to them and, of course, enlarge and extend them to suit their own peculiar needs. Similar arrangements are found in the fern *Phymatodes schomburgkii* found on the Rio Negro; and in a Polypodium found by Dr. Jameson on the river Napo.

But even more minute creatures than ants have been provided for by plants. We have headed this chapter "Plants and Insects," and we are about to introduce into it creatures that are not insects; but it seems to be the most appropriate place in which to refer to the Mites. Being very small, the non-scientific public have always persisted in regarding them as insects, so that after all this is the most likely place in the book in which they would be sought. The Mites are regarded generally as troublesome little things that are always working mischief of some sort—viewed from the human standpoint, of course; but in many ways they are beneficent creatures, doing good work

PLATE 42 LEAF OF LIME. Page 146

The small white crosses mark the position of the Domatia in the angles of the ribs.

Photo by Author.

as scavengers and as destroyers of noxious germs. In truth, we are far too ready, in the case of any small animal whose life and work we do not understand, to jump to the conclusion that its existence is a part of the primal curse pronounced on Man, and that we must be ever vigilant to destroy all things that creep and crawl and fly. It is believed by those who have paid some close attention to them that many of the Mites are engaged in the laudable work of hunting for the germs of fungi, noxious Bacteria and the like, that are ever settling on the leaves of trees, and would, if left alone, develop and cause serious troubles of various kinds. Many trees have found out that Mites which merely run over their foliage and hunt for germs of this sort are to be encouraged, and so in designing their foliage they have made arrangements for the comfort of these little guests. If you will pluck a leaf of Sycamore or Lime, and look at its underside, you will see in the forks where the secondary ribs run off from the thick midrib, a fringe and tuft of hairs. Probably you have noticed this before and dismissed it as so much meaningless ornamentation of the leaf; though it appears that no natural decorations are meaningless or without purpose. These tufts and fringes are

sheltering masks to snug little retreats which extend under the rib-fork and slightly into the leaf-tissue beyond. In the hotter part of the day these "domatia," as they are termed, are inhabited by the guardian Mites, who wander in search of their germ-prey at night. It is probable that originally these retreats may have been excavated by the Mites, but as they were regularly recurring mutilations of the leaf they became hereditary. If you examine the back of one of these leaves, you will see one or two of the Mites, perhaps in the centre of the leaf; but if with a stiff hair you probe under the tuft and into the recess you will drive out several others. If your examination be made in spring, as soon as the leaves have expanded, but before they have attained to full size, you will find that these "domatia" are not excavations but natural developments, provided for in the making of the leaf.

If the reader has examined some of these domatia for himself, and stirred up the Mites to assure himself of the use to which these retreats are put, he will be quite prepared to learn how certain plants of South America have improved considerably upon this idea in making provision for their ant friends. In some species of Melastoma

studied by Belt, domatia of a larger size are provided, not for Mites but for Ants again. At the base of the leaf the leaf-stalk is swollen, and the swelling is hollowed into two pouches, separated by the midrib and entered from the lower side of the leaf. Every pouch Belt examined he found occupied by small black ants. If he touched the leaf ever so lightly the ants would rush out and scour it all over in search of the aggressor. In some of these pouches he found in addition to eggs and young ants, a number of aphides.

Richard Spruce, the botanist, spent several years along the river Amazon and the Andes, and was interested greatly by certain phenomena he noted in connection with a genus of plants named Tococa. There are a number of species which form weak bushes from eight to twelve feet in height, and growing on such low land between the river and the forest as is liable to be inundated by the rise of the river and lakes during the rains. Spruce wrote an account of the remarkable way in which the Tococas and some other plants of that region have laid themselves out for the accommodation of ants, and this was read before the Linnean Society of London in 1869, with the title of "Ant-agency in Plant Structure."

The Tococas have large, thin, lance-shaped leaves, sparsely clothed with long hairs, and these leaves are disposed on the stem in pairs (*opposite*). They have prominent ribs branching off from the midrib, as in our domatia-bearing species, and the lower part of many of the leaves bears one or two sacs. Where there are two sacs these usually unite to form one chamber in the leaf. At the forking of the ribs there is a little tunnel in *Tococa disolenia*, as in domatia, leading into this chamber, which is inhabited by a small brown species of Ant "which pour out of the tubes and patter over the leaves to attack any animal that disturbs their domicile." In most species the tubular way is wanting, access to the chamber being obtained by direct openings in the rib-forks. The brown Ants, which bite but do not sting, appear to be common to most species of Tococa; but Spruce describes one species (*Tococa bullifera*) which has "minute reddish Ants which are fragrant when crushed." This Tococa is of dwarfer growth, not exceeding five feet in height, and its berries "are more juicy and better flavoured than in any other Tococa, although so scanty and perishable that they cannot possibly serve as food for ants except for a very short period,

and can hardly have influence on them in the choice of an abode."

Altogether Spruce found twenty-four or twenty-five species of Tococa, and all but one were provided with these Ant chambers. The exceptional species, *Tococa planifolia*, grows along the shores of the Rio Negro, always occupying the very edge of the riparial forest, where it is completely submerged in the time of flood. All the other species grow so far away from the real shore of the rivers or lakes that they are never completely submerged, though their lower parts are. In these sac-bearing species there is always a refuge for the Ants in the upper leaves, which are always out of reach of the water. Obviously, under these conditions, it would be useless for *Tococa planifolia* to develop Ant chambers; and the existence of this exceptional species is of the greatest value in showing us *why* the others have evolved such a convenience. *Tococa planifolia* is not merely an exception which proves a rule—which exceptions do not always succeed in doing, in spite of the proverb—but it shows clearly the purpose of these sacs in the other species and helps us to see how they originated.

The first leaves of every species of Tococa are without these sacs, and they are never produced

on the lower branches, because these are liable to be submerged and Ants inhabiting them would be drowned. Spruce's view was "that the primeval Tococa—the ancestor of all the existing species—had no sac at all on the leaves, but that a few Ants having sheltered in the deep narrow angles formed by the junction of the prominent lateral ribs with the midrib, found the axils perforable, and having thereby reached the interior of the leaf, scooped out the parenchyma between the two surfaces. The leaves of any plant, when its juices are sucked away by insects (Aphides, for example) or otherwise diverted from their usual course on the one surface, are apt to become bullate on the opposite surface; hence it is easy to understand that, when mined by Ants, the cuticular tissue of both surfaces should expand outwardly and contract laterally so as to form a sac whose further enlargement would be effected by the continual crowding in of the Ants. This process repeated on the plants for many generations would [through the survival of the fittest] induce an hereditary tendency to the production of sac-bearing leaves. . . . I have often examined *half-grown plants and have seen that sacs begin to be developed by inheritance long before any Ants touch them*, but that when

the sacs are taken possession of by Ants they speedily become much enlarged."

He goes on to remark that the species of Tococa which grow "far enough inland to maintain their heads above water even at the height of flood are thereby fitted to be permanently inhabited, and are consequently *never destitute of saccate leaves*, nor at any season of the year clear of Ants; as I have reason to know from the many desperate struggles I have had with these pugnacious little creatures when breaking up their homes for the sake of specimens."

But the Tococas are not the only species of plants inhabiting this region that have developed these Ant-homes on their leaves. There are the Myrmidones, "found in the forests of humble sparse growth called 'caatingas,' and especially where the soil of white sand, or the granite floor almost bare of herbs, lies low and is liable to get transformed into a shallow lake in the time of heavy rains, thus driving Ants and other insects to take refuge in the trees and bushes." They are low-growing, sparingly-branched shrubs, from three to eight feet in height, and their leaves and stems are covered (more copiously than in Tococa) with red or crimson hairs "corresponding curiously

with the colour of the minute Ants—of that viciously-stinging tribe called ‘Formiguinhas de fogo’ (Little Fire-Ants)—which inhabit the sacs, and also make covered ways of intercommunication along the outside of the stem and branches—a precaution I have rarely noted among the Tococa-dwellers.”

Majeta guianensis is a somewhat similar plant, but its branches are hollow, pipe-like, with swellings where each pair of leaves is given off, so that the Ants have here already provided for them a covered way in the interior of the branch.

Hirtella physophora, a slender small-tree, which grows just within reach of inundations in the forests near the mouth of the Rio Negro, has a pair of roundish sacs at the base of its long leaves, and these are tenanted by Ants. “On cutting open the sacs I was rather surprised,” says Spruce, “to find them lined with cuticular tissue and hairs, just like the underside of the leaf; which seems to show that they have been produced by a recurvation of the leaf, through the ants nestling at first (Aphis-like) under the leaf and causing it to become bullate, and that the recurved margins have at length reached and coalesced with the midrib so as to form a pair of sacs.” A similar pair of sacs

is found on the base of the leaf in *Amaiona saccifera*, an unrelated small bushy tree, growing in caatingas on the Rio Negro. The sacs are inhabited by red Fire-Ants, which also suck the juices of its plum-like fruit. *Remijia physophora*, a tree found at the falls of the Uaupés, has a single Ant-sac on its leaves.

Spruce remarks of these sac-bearing trees and shrubs: "In all the plants I have seen bearing sacs on the leaves, to whatever order they belong, it is remarkable that the pubescence consists of long hairs having a tubercular base; and although I do not see what connection that peculiarity can have with the Ants' choice of a habitation, it is probable they find some advantage in it." We have not seen these plants, and it is perhaps rash, therefore, to venture an opinion, but it seems to be not improbable that the "tubercular bases" of the hairs indicate glands from which some secretion exudes for the Ants to lick.

Two genera of trees belonging to the Pea family (Leguminosæ)—Tachigalia and Sclerolobium—have the base of the three-sided leaf-stalks dilated into a spindle-shaped sac tenanted by small black Ants. The attraction to the Ants in these cases—plus their ready-made habitations—appears to be the

abundant and long-continuing honey-scented yellow flowers.

One of the Cordias (*Cordia nodosa*) is known to the South Americans as the Ant-tree, owing to the fact that it provides Ant-sacs on its branches which are tenanted by the Fire-Ant. Another (*Cordia gerascantha*) rises to a height of thirty or forty feet, and its branches start off in whorls of three, four, or five from regular points on the stems. Just below one of these whorls the stem or branch is inflated into a sac inhabited by vicious Ants known to the Brazilians as "Tachi."

Spruce found that all the species of Cordia that had their branches so arranged, had Ant-sacs, and were also more or less covered with long coarse hairs; but in the species whose branching followed no very definite order, and whose hairs were short and soft, there was no provision of any kind for an Ant habitation. One of the Potato family (Solanaceæ), known as Marckea, which grows on the Rio Negro, is similar in its arrangements to Myrmecodia in Malaya. Its stem "is reduced to a large tuber—sometimes as big as a child's head—and attains that size through the agency of Ants, who inhabit its hollow interior and cover it outwardly with paper of their own

manufacture." Branches radiate from the tuber and have perforated swellings at the forks, which serve as detached apartments for the Ants.

The larger Polygonums, of which several have been introduced into our gardens and shrubberies, where they are remarkable for the rapid growth of their tall annual stems, are represented in Equatorial America by both trees and herbs. They like a moist situation, and most of them grow on land subject to inundation. Every one of the woody species has its stem from base almost to growing tip hollowed out by Ants. They enter the stem where it is young, and advance with its growth into the branches, all of which they hollow out. The Ants are long and slender, dark-coloured and glossy, and sting with virulence. They are known as Tachí and Tangarána in Brazil and Peru respectively, and these names are also applied to the trees they inhabit. One of these Polygonums—*Triplaris surinamensis*—is a tree of rapid growth whose ultimate height is a hundred feet, and is found all along the Amazon; whilst *Triplaris schomburgkii*, a smaller tree, grows along the Upper Orinoco, etc. Both of them, and some other trees of the same family, have slender tubular branches with small perforations, which are used

by the Ants for egress and ingress. They have their habitations inside, and they are for ever patrolling, not only the branches, but the main trunk also, "as the incautious traveller finds to his cost when, invited by the smoothness of the bark, he ventures to lean his back against a Tachí tree.

The identity of these "Tachí" Ants has been established since Spruce's time. Forel says: "Through the investigations of Mr. Ule the fact becomes more and more firmly established that a definite group of *Pseudomyrma* species (*arboris-sanctæ*, *dendroica*, and *triplaridis*) lives symbiotically in the natural medullary cavities of *Triplaris*. I myself observed in Colombia how *P. arboris-sanctæ*, var. *symbiotica*, fiercely attacked any one who touched the tree. Their brood filled the whole living tree from the trunk to the smallest green branches. They seemed to have entered this secure and ramifying domicile through a small dead and broken branch on the lower part of the trunk."

Even man benefits to some extent from this association of Ants with trees. Spruce tells us of some Mabeas that have very long twiggy branches, which are inhabited by Ants, that the slender twigs hollowed out by the Ants are so polished

inside that they make favourite material for pipe-stems, and are sold in bundles in the Para shops. He says that nearly all the tree-dwelling Ants, although in the dry season they may descend to the ground and make their summer-houses there, retain the sacs and tubes as permanent habitations; and some kinds of Ants appear never to reside elsewhere, at any time of year. The same is probably true also of Ants which build nests in trees, of extraneous materials, independent of the growing tissues of the tree itself. "There are some Ants which apparently must always live aloft; and the Tococa-dwellers continue to inhabit Tococas where there is never any risk of flood, as in the case of the *Triplaris pterocalyx*, which grows on wooded ridges of the Andes. Their case is parallel to that of the lake-dwellers of the mouth of the Orinoco and the inundated savannahs of Guayaquil, whose descendants must needs elevate their houses on stages six feet or more in height, although nowadays erected on rising ground far beyond the reach of river floods or ocean tides. We call this 'instinct' in the case of Ants, 'inherited custom' in the case of men; yet there is obviously no difference."

Dr. Alfred Russel Wallace, who has recently

(1908) edited Spruce's *Notes of a Botanist*, says on this subject: "I think the facts that have now been observed in both the western and eastern tropics are really sufficient to enable us to understand the probable origin of the various remarkable structures that have been developed in many different groups of plants and are utilized by Ants. There is clearly 'utility' on both sides. The Ants obtain dwellings, protection from floods, a safe shelter for their eggs and larvæ, and a portion of their food—in some cases perhaps all—from the plant they inhabit; while the plant derives protection to its foliage, and perhaps also in some cases to its flowers—as shown by Kerner—by the presence of whole armies of virulently-stinging Ants, whose very minuteness renders them the more formidable."

Mr. W. M. Wheeler, who has written the fullest account of Ants yet published, thinks that these relationships are all compatible with the view that the Ants have adapted themselves to the plants, but that the converse of this proposition is in most, if not in all, instances open to doubt.

IX

ANTS AS HOSTS

IX

ANTS AS HOSTS

We have already seen that the intelligent Ants have made it worth while for a number of different species of plants to make special arrangements for their comfort. Given the fact of such a phenomenon as commensalism existing among insects we should be prepared to say offhand that the Ants would certainly be to the fore in availing themselves of its advantages. Many years earlier than the first appearance of the word commensalism in scientific literature it was a well-known fact that certain beetles could only be found in the nests of ants, and that others passed their larval existence there, though the reasons for this strange habitat were not apparent. Indeed, at the present time, when a great deal of investigation has been made into the matter, and long lists have been compiled of species that spend all or part of their lives in Ants' nests, little is really known of what they do

there, or of the exact conditions governing their existence. It is evident that this must largely continue to be the case, for though the Ant has been, so to speak, domesticated by investigators like Avebury, Wheeler and Donisthorpe, who keep the Ants' nests under constant observation, the Ants so strongly object to the light of day entering their galleries and chambers that it is impossible to know accurately what takes place in these recesses.

But all the Ants' friends and protégés are not underground, and from what is known and well-attested of their relations with other insects above the surface, it is not difficult to arrive at conclusions respecting their friendships below. From the days of Goedart (1685) and Huber it has been known how they plant out colonies of Green-fly and protect them from enemies, the Green-fly in return exuding drops of honey-dew for the Ants' refreshment when asked to do so. There are many species of *Aphis*, and though it may be convenient to speak of them all as Green-fly they are by no means all green. There are reddish-brown Aphis, grey Aphis, and black Aphis. Most of the species have special tastes in the way of food, and are only found on particular plants; some preferring herbs,

some shrubs and some tree-foliage. Some attach themselves to the roots of plants underground. Many years ago we planted some carnations in the garden, and because they were a choice kind we planted them with great care. But after a short time one of these plants that had been healthy and vigorous began to sicken and dry up. There was no apparent reason why this plant should not flourish as its fellows were flourishing; so we investigated by carefully digging up the dying plant. To our astonishment, we found that the roots were suspended in an underground space almost as large as a cricket-ball, and they were coated with a thick crowd of a grey species of Aphis (*Forda formicaria*). A number of yellow Ants (*Lasius flavus*) were running about the cavern, and we have little doubt that they were the excavators who had hewed out and carried away that great mass of earth—great, that is, in proportion to their own small bodies and implements. No doubt they had also brought the Aphides, or the progenitors of that crowd, and had placed them on the carnation root as a sort of underground dairy-farm. The finer branches of the roots had disappeared completely, and these had probably been cut off by the Ants and eaten. There was

no room for wonder that the carnation had failed to keep its health under such conditions.

About the same time we were interested in a colony of Green-fly that was pastured on the new growths of a black-currant bush, because we had noticed that a number of Ants were constantly coming and going between this new shoot and the ground. What seemed to us a peculiar thing happened; the new upper leaves as they expanded, instead of the leaf-stalks standing out almost at right angles from the stem, began to curve downwards and the tips of the leaves to turn in towards the stem, so that three or four leaves formed the boundaries of a hollow sphere around the stem. It was not a wilting of the leaves; they retained their fresh crispness, but the midrib and leaf-stalk were curved. A close examination led us to believe that these had been carefully bitten by the Ants on their under surface, which had stopped, or hindered, growth on that side, and so produced curvature by the greater extension of the upper-side. This had the double effect of concealing the Aphides from the chance observation of insectivorous birds, such as the tits, and protected them from the devastating effect of heavy rains.

Buckton, in his monumental *Monograph of*

the British Aphides, has a chapter on Aphides in their Economical Relations to Ants, and speaks of what we now term Commensalism as Favouritism, Sycophancy or Paracletism to distinguish it from parasitism. But Buckton was not alive to the full significance of this friendship, or perhaps he was afraid of being led away by imagination to give a greater value to it than the strict duty of a scientific chronicler justified. He seems more inclined to regard the association as fortuitous, or at the most dictated by the Ants' greed for sweets, and fails to realize fully that the Ants' selfish care for the Aphis is not merely useful to these helpless insects, but in all probability ensures the race against extermination. In such matters we have moved forward a bit and learned much in the thirty years that have passed since Buckton wrote, and though we may admire his caution, it is difficult to see how with all the evidence of Huber, Kirby and Spence, Westwood and Lubbock (now Avebury) before him, he could not be a little more generous towards the Ant.

Pierre Huber told how certain European Ants wall in with earth portions of leaves that are occupied by Aphides, and clear cavities around the roots of grasses and other herbs to which sub-

terranean species of Aphides are attached. He declared that some Ants build covered ways leading from their nests to colonies of Aphis on distant plants, so that they can visit them at all times without exposure, and that a red Ant near Geneva formed spherical tents of earth around thistle-heads that were infested with Aphis. Near the root of a thistle he discovered an earthen cylinder, two and a half inches by an inch and a half in size, which enclosed many Aphides and attendant Ants. Similar covered erections and tunnels he found in various situations above ground and along tree branches, sometimes fabricated out of decayed wood instead of earth. He declared that Aphides are the domestic animals of the Ants. He found that the Ants collect the eggs of the Aphis and store them through the winter, taking every precaution to preserve their vitality; and that on the return of spring they place them in suitable conditions for hatching. He discovered that the Ants of neighbouring nests have frequent disputes as to the possession of the Aphides; that they burglariously enter the dwellings of their neighbours, and if possible make off with their domestic animals. Buckton seemed doubtful as to this winter care of the Aphis eggs; but it does not

rest entirely upon the evidence of Huber. Kirby and Spence say—or one of them says, for it is impossible to assign any part of their work to either author in particular: "Once upon opening one of these ant-hills early in the spring, on a sunny day, I observed a parcel of these eggs, which I knew by their black colour, very near the surface of the nest. It is of great consequence to them to forward the hatching of these eggs as much as possible, in order to insure an early source of food for their colony; and they had, doubtless, brought them up to the warmest part of their dwelling with this view." Lubbock also found that *Lasius flavus*, our Yellow Ant, collects Aphis eggs and stores them for perhaps six winter months. He noticed that, on hatching, whilst some of the Aphides crawled out of the nest on their own account in quest of food-plants, others were taken out by the Ants and placed on suitable plants, where they throve. In a communication to the Linnean Society, Sir John Lubbock described the hatching of these eggs—never before observed—and the conduct of the Ants (*Lasius flavus*) to the Aphides: "Near one of my nests of *Lasius flavus*, in which I had placed some of the eggs in question, was a glass containing living specimens of several species of

plants commonly found on or around ants' nests. To these some of the young Aphides were brought by the ants. Shortly afterwards I observed on a plant of daisy, in the axils of the leaves, some small Aphides very much resembling those from my nest, though we had not actually traced them continuously. They seemed thriving and remained stationary on the daisy. Moreover, whether they had sprung from the black eggs or not, the ants evidently valued them, for they built up a wall of earth round and over them. So things remained throughout the summer; but on October 9 I found that the Aphides had laid some eggs exactly resembling those found in the ants' nest, and on examining daisy plants from outside, I found on many of them similar Aphides and more or less of the same eggs. I confess these observations surprised me very much. . . . Here are Aphides not living in the ants' nest, but outside on the leaf-stalks of plants. The eggs are laid early in October on the food plant of the insect. They are of no direct use to the ants, yet they are not left where they are laid, where they would be exposed to the severity of the weather and to innumerable dangers, but brought into their nests by the ants, and tended by them with the utmost

care through the long winter months, until the following March, when the young ones are brought out and again placed on the young shoots of the daisy. This seems to me a most remarkable case of prudence. Our ants may not perhaps lay up food for the winter, but they do more, for they keep during six months the eggs which will enable them to procure food during the following summer."

In spite of all this, Buckton, who it must be confessed was a student of Aphides rather than of Ants, says: "Perhaps the only safe conclusion arrived at with reference to Aphis and Formica is, that the latter is a considerable sugar consumer, and that, like Man, it also is a fosterer of pets and favourites." We contend that it is a thoroughly good case of Commensalism, each party to it benefiting by the association. The Aphides are an ancient race, and there are geological evidences that in the Mid Tertiary period Ants made use of them as they do now. Having regard for their delicate unprotected bodies, their want of jaws, stings or other organs of offence or defence, they must long ago have become extinct under the assaults of their numerous enemies, but for the protection of the Ants. Interfere with any of the plants upon which they are feeding, and you will

find that there is an Ant-guard on the watch, and that were you something less than man you would probably be repulsed. Man as you are, the Ants are not afraid of you, but will seize on your fingers with their jaws and make futile attempts to drive you off. That is the service the Ant partner renders to the feeble Aphis. Let us see what is the nature of the Aphis' return.

On the upper part of the hind body there is a pair of protruding tubes (called cornicles) directed backwards. Through these little hollow horns it was supposed that the Aphis can at will pour out drops of a sugary fluid of which the Ants are very fond, and which they carry to the nest in order to feed the Ant-larvæ with it. It is now known, however, that the secretion from the cornicles is a solution of wax, and ejected at their enemies, not their friends; the sugary solution coming from the anus. Ants go out from the nest in procession to the place where their Aphides are stationed—it may be high up in the branches of a tree, a relatively long distance when measured by the Ant's length. Approaching an Aphis, they make certain caressing strokes upon it with their antennæ, and the Aphis at once ejects some of the desired fluid, which is sucked in by the Ant and

PLATE 43 ANTS AND APHIDES. Page 172

The Ants are visiting a colony of Aphides and collecting honey-dew from them.

By T. Carreras.

taken to the nest, where it is regurgitated from its mouth into that of a larva. The Ant's abdomen is capable of considerable distention, so that it is able to carry back a considerable quantity. We have often watched an ascending line of Ants of ordinary dimensions on one side of the trunk of an apple-tree, whilst on the other side a descending line had abdomens of about twice the circumference. They were some of the same party, but these had visited their Aphides on the apple leaves and had filled their crops with Aphis-honey (honey-dew). Seeing that some Ants can live entirely upon such sugary fluids, it will be seen that they have every inducement to take care of the Aphis, and that it must be a great convenience to have some of the subterranean species handy upon roots that penetrate into their nests or adjoining runs; and that the old authors who described the Aphis as the Ant's cow were not without justification for the analogy. But it should be stated that Ants of carnivorous habit and fungus-growing Ants set no store by honey-dew.

The question arises, seeing the convenience of having these food-providers in the nest, how is it that the Ants have not restricted their attentions to the preservation and improvement of the under-

ground species instead of planting colonies on plants above ground and often at a distance? That is a question which we cannot answer with any certainty, but we may venture the suggestion that the supplies obtained from underground species like *Forda formicaria* may not be as nutritive as from the leaf- and shoot-feeders. A botanist would tell us that sap taken from the roots, consisting largely of water taken up from the soil, could not be so rich in food constituents for animal consumption as the elaborated sap in the shoots and leaves; and therefore by itself it may not be sufficiently nourishing. It is a fact that the Ants that make use of this species are mostly small, like *Lasius flavus*. It should be stated here in order to avoid any misapprehension, that the Rhizobiinæ, the section of the Aphis family to which most of the underground species belong, are not provided with the pair of cornicles from which the other species eject wax; and this is probably explained by the fact that in the underground cell they are completely protected by their ant friends, and have no enemies to repulse.

Forda formicaria has actually got an English name, being distinguished as the Ant-Aphis, to mark the fidelity with which it frequents the

fibrous roots of grasses and other herbs in, or in immediate proximity to Ants' nests, particularly those of *Lasius flavus*. It has also been found in the nest of the big Wood Ant (*Formica rufa*), and in those of *Formica rubra* and species of *Myrmica*. An allied species, *Forda viridana*, is found in quantity nesting with *Formica fuliginosa*; and in Germany Wasmann has found it with *Lasius flavus*. Several species of *Tychea* and *Endeis* have been found in similar situations; and *Lachnus formicophilus*, a species of Aphis hitherto unrecorded as British, was found by Mr. Donisthorpe when exploring nests of the Wood Ant at Oxshott, Surrey, some years ago.

It appears that the Ants' solicitude for the autumn-laid eggs of the Aphis—in the summer no eggs are laid but the young are born alive—is less for the protection of the germs from frost as from a desire to plant new colonies in the most convenient places, as the eggs are obviously more easily dealt with than the active young—though they do, on occasion, remove the young. Aphides have been carefully exterminated by washing certain trees, but the owner has found, almost immediately after, the Ants re-stocking what was to them evidently a satisfactory pasturage.

This attachment between the Ants and the Aphides is without doubt answerable for much of the annoyance caused to the gardener and agriculturist, for the Green-fly are found in enormous numbers in situations where they would seldom be if their distribution depended on their own powers. The Ants make a business of planting out colonies in all sorts of favourable situations. Hear what Mr. F. M. Webster says of the manner in which *Aphis maidi-radicis* becomes a pest to the growers of Indian Corn in the United States:

"Now, taking up the life-history of the root-Aphis, we find eggs in the fall, it is true, but only in the burrow of and attended by these ants. If there are eggs, egg-laying females, or males elsewhere they have yet to be discovered. The ants care for these eggs throughout the winter, shifting them about, according to Forbes, as they do their own young, to accommodate them to changes of weather and moisture. In spring, the young, as soon as they hatch from these eggs, are transferred by the ants to the roots of young fox-tail grass, smartweed and even ragweed. The young are carried out to pasture, as it were, during fair weather, but in bad weather, or on cold nights, they are taken back to the burrows of the ants.

PLATE 44 — AN UNDERGROUND ANT DAIRY. — Page 176

Some Ants pasture their "cows" on the roots of grasses and other herbs, enlarging their burrows to accommodate them.

By T. Carreras.

The plants just mentioned are the ones that push up early in the spring in last year's corn lands, and especially in fields that have been ploughed and allowed to stand untouched for a week or two. Usually the farmer ploughs his ground in spring and pays little attention to this early growth of weeds and grass, as he can generally dispose of it as soon as he begins to cultivate his corn, although this is not until the rows of young plants can be followed by the eye across an ordinary field. As soon, however, as the corn plants begin to show above ground the ants not only transfer the young root-aphids from the burrows to the roots of corn, but they will also remove them from the roots of grass and weeds and recolonize them on the roots of young corn. Now these young aphids are all females, and within a few days they begin to give birth to young, also all females; these, too, are cared for by the ants, which place them on the freshest and most tender rootlets. This procedure goes on about the roots of corn throughout the spring and summer."

No fewer than seventeen distinct species of Aphis have been recorded as living actually in the nests of various Ants. As to the amount of honey-dew they produce to make it worth while for the Ants

to watch over and protect them, it has been found that the Lime-tree Aphis will give nineteen drops in twenty-four hours, and the Maple Aphis forty-eight drops in the same period. In most cases this honey-dew is used to supplement other food, but the Ant known as *Acanthomyops* subsists upon this food entirely, and Mordwilko asserts that the Ant *Lasius brunneus* is entirely supported by the Aphis *Stomachis.*

Scale Insects and Tree-Hoppers also come under the protection of various species of Ants who are actuated by similar considerations as in the case of the Aphides. The Scale Insects, it is true, do not appear to be in much need of protection, for the horny scale which gives them a name is an efficient armour whose edges are applied closely to the plant surface upon which they feed. Nevertheless, they appear to find it worth while to provide honey-dew for the Ants. So, too, with other Coccids, which are protected by secretions of wax. In warm countries they are watched over particularly by the Ants that build their nests on the branches and trunks of trees. Some Coccids, like some Aphids, are subterranean, such as the "earth-pearls" (*Margarodes*), which Guilding and Trimen found associated with Ants in St. Vincent

and South Africa. The association is no new thing, for there are many examples of Ants in company with Aphids and Coccids preserved in amber. Tree-Hoppers in the United States are constantly cared for by Ants who build protecting sheds of earth and tents of silk or paper-like material over them. The Lantern-fly family (Fulgoridæ) also furnishes ant-friends. Two species of *Tettigometra* (*T. impressifrons* and *T. costatus*) are guests in the nest of a little Ant, *Tapinoma nigerrimum*, where they feed upon roots, and give out a sweet fluid from a number of glands.

In tropical countries, where they take the place of the Aphis as sap-sucking plant-pests, the Ants make use of Scale Insects (*Coccus*) in a similar way, and protect them from enemies. Prof. T. D. A. Cockerell alludes to this point in describing *Icerya rosæ*, a Jamaican Coccid, "at the present moment some of these *Iceryæ* are enjoying life, which would certainly have perished at my hands but for the inconvenience presented by the numbers of stinging Ants." A British species, *Lecanopsis formicarium*, has been found in the nest of the Ant *Lasius niger*. Newstead has obtained *Ripersia subterranea* from the nest of *Lasius flavus*; and Donisthorpe added *Ripersia tomlini* to the British

list by finding it in numbers in the nests of *Lasius niger*.

But not all the insects and other small fry that are to be found in Ants' nests are commensals. Wasmann in Germany, Wheeler in the United States, and Donisthorpe in this country have published extensive lists of the creatures they have found commonly as tenants of the nests of various ants (Wasmann has the names of nearly 1,200 insects that are lodgers of various denominations in Ants' nests), and a consideration of these lists leads one to regard the Ants' nest as a sort of poor-house for the lower orders of animal life. In the poor-house one finds a very mixed assembly, not all of whom have come in at the invitation of the master of the house, but because a refuge of some sort was a necessity. So it seems to be with some of the tenants in an Ants' nest. Some are blind or feeble and unable to do battle with the world outside; some are able to accept the labour test and act as housemaids; others apparently are mere lazy loafers, content with what they can get to eat, but not eager to render service in return. With these we are not concerned just now; but it is proper that they should be mentioned, for their presence is evidence that the Ant has a soft side

to his character. Most people know him as a pugnacious little fighter, always ready to resent any encroachment in his territory, by fixing his jaws in the intruders or ejecting burning drops of formic acid at them. With most of these intruders or visitors, call them what you will, it would be an easy matter for a host of Ants to destroy them; but the nest owners have apparently satisfied themselves that they are not there with any evil intent, and they extend to them a kindly tolerance. If danger threatens their nest—for example when a truth-seeking naturalist is digging it up—they seize their offspring in their jaws and attempt to escape. Their legitimate lodgers or messmates they endeavour to save in the same manner; but the uninvited, non-reciprocal guests they leave to shift for themselves.

Among these visitors who, as far as can be ascertained, are not messmates is one of the round-backed Millepedes, known as *Blanjulus guttulatus*, which Mr. Donisthorpe reports as often present in the nests of *Formica rufa* and *Lasius fuliginosus*. Mr. F. G. Sinclair suggests as a reason for their presence that they find the quality of the earth in these nests peculiarly suitable for the construction of their egg-nests. Several species of the False

Scorpions or Chelifers are also there, but probably only feeding on rubbish. Abroad, various species of grasshopper in the larva stage have been found regularly inhabiting Ants' nests.

It is rather strange to find small species of Ant taking advantage of the industry of larger species; but *Solenopsis fugax* tunnels galleries for its own nest actually in the walls of the nests of *Formica fusca* and other of the larger species—the idea evidently being that the host cannot get into their small galleries to eject them. Among other small Ants that pursue similar tactics may be mentioned *Formicoxenus nitidulus* in the nests of *Formica rufa* and *Formica pratensis*; *Leptothorax acervorum* and *L. nylanderi* in the nests of *Formica rufa* and *F. fuliginosa*; *Myrmica scabrinodis* in nests of *Formica flava* and *F. sanguinea*; *Myrmica lævinodis* in the nest of *Formica rufa*, and *Myrmecina latreillii* in the nest of *Formica niger*.

Different species of Ants are known upon occasion to engage in war with one another; but they can also live in peace as near neighbours. Donisthorpe tells how he found *Lasius flavus* and *Lasius fuliginosus* with nests in the same hollow tree and having to use the same crevice as a common en-

trance. A good *casus belli* here had they been of unfriendly disposition.

Beetles as inhabitants of Ants' nests have long been known. Kirby and Spence were able to speak of sixteen or seventeen different species of Ant-nest Beetles being known in their time, and André in 1874 increased the number to 542. Wasmann (1898) makes it 993! *Claviger testaceus* was the first of these to be discovered by Müller in Germany, who published an account of it in 1818; and Westwood soon found that it existed in this country in similar situations, that is to say, in the nest of the Yellow Ant (*Lasius flavus*). The beetle is yellow like its host, and several characters point to the probability that the species has been modified by life in Ants' nests extending back for ages. Its eyes have become completely atrophied by disuse; its wings have vanished, and the short wing-covers have become soldered together. At the edge of these wing-covers (*elytra*), which in this case do not cover wings, is a tuft of hairs among which are excretory glands. Now, that the presence of these beetles in the Ants' nest is not a matter of kindly toleration, but that they are there by desire, is shown by the fact that when the nest is disturbed the Ants show as much anxiety to remove their

Clavigers into the safety of the lowest galleries as they do to protect their own larvæ and pupæ. They feed the beetle with food from their own crops whenever he expresses the desire for it by touching them with his antennæ. On the other hand, the beetle secretes a sweet fluid from its glands, and this gathers in a pearl-like drop on the tuft of hairs where the Ant can lick it up. Here is a case in which one partner has become solely dependent upon the other. There can be little doubt that but for the protecting care of the Ant, the Claviger must cease to exist, for it appears to have lost all capacity for an independent existence, and has never been found outside the Ants' nest.

Many other beetles are found in the nests of various species of Ants, but in most cases they are uninvited or undesired interlopers, there for their own advantage only, and offer no benefits to their unwilling hosts for house-room. These have to keep out of the way of the Ants as far as possible, or they get destroyed. This has been tested by introducing beetles dug out of their lurking places in Ants' nests into observation-nests, where they are at once seen and pounced upon by the Ants, who kill them. Lubbock is of opinion that some of them, though of no practical value, may be kept

PLATE 45 — Page 184

ANT AND ANT NEST BEETLE.

Lomechusa lives entirely in Ants' nests, and is fed and cared for by the Ants.

Photo by H. K. Donisthorpe, F.Z.S.

by the Ants as pets, just as we keep useless toy-dogs, guinea-pigs and white mice. But there are some species which, like Claviger, are honoured guests. Among these is *Lomechusa strumosa*. Kirby and Spence relate how their friend, M. Chevrolat, had obtained this beetle among others from the nests of *Formica rufa* near Paris; and in this country single specimens had been obtained by Sir Hans Sloane (1710) and Dr. Leach (1820) respectively. Nothing more was heard of it here for more than eighty years, probably because it had not been sought for in the right place; for it passes the whole of its life in the nest of the slave-making Blood-red Ant (*Formica sanguinea*). It dropped out of the lists of British Coleoptera, the authorities considering that the two previous captures were accidental, that is to say, due to a fortuitous introduction of these specimens from the continent. However, in the spring of 1906 Donisthorpe, when exploring a nest of the Slave-maker at Woking, was delighted to find Lomechusa in its depths, and since then, in the same locality, he has found it again and again. On one of his raids a single nest yielded over sixty specimens of this beetle, and with this wealth of material he has been enabled to give us a good account of its relations with its hosts. To

his description we are indebted for the facts of the following story—as well as for much else in this chapter.

Lomechusa is one of that section known as Rove-beetles (*Staphylinidœ*) which, except for the absence of nippers from the hinder extremity of the body, look much like small Earwigs, the wing-covers not extending halfway over the back, and some of whose smaller members have an unpleasant trick of blundering into the human eye in summer. Lomechusa has not been degraded by its habits to a condition of servile dependence upon its hosts, like Claviger. It has retained its wings, and with the use of them its liberty. It is free to go or come as it pleases, and it elects to spend its days in the Ants' nest. It leaves only for the purpose of furnishing other nests with its progeny. Seen by itself, it bears no resemblance to an Ant, but it likes to sit among a crowd of its hosts, and then assumes such an attitude that it is easily passed over as one of them—and this probably explains why it was for so long regarded as non-existent in these islands. In this matter it is helped by its colour—a reddish-brown—which presents no strong contrast to the colour of its hosts. This point is worthy of note, as it is a parallel to the yellow

colour of Claviger which agrees with that of *its* host, the Yellow Ant (*Lasius flavus*) ; and suggests that in the beginning of these commensal habits similarity of colour may have played an important part in inducing the Ants to tolerate these strange visitors.

On the segments of the Beetle's hind body there are orifices from which a sweet fluid exudes, and these orifices are covered by tufts of golden hairs. An Ant meeting Lomechusa begins to stroke it with its antennæ, upon which hint the Beetle pours out a small quantity of its sweets and the Ant licks it up. In similar fashion the Beetle will walk up to an Ant, tap it with its feelers, just as one Ant does to another when food is desired. Ant and Beetle bring their mouths together, and the Ant supplies food from its crop to the Beetle. But this supplication for food from the Ant must not be taken as implying that the Beetle cannot look after itself in this respect. It has been seen to feed on dead Ants, and on caterpillars and other small creatures that have been given to the Ants as food.

The Beetle's eggs are laid in the Ants' nest, and are very similar in appearance to those of the Ant. So are the grubs that issue from them like the

grubs of the Ant, except, of course, that they are provided with six short legs whilst the Ant-grubs are not. But the Beetle-grub does not use his legs, and in all ways bears himself as though he were an Ant-larva and is treated by the Ants as such, being licked and fed from their own mouths. At this stage of his existence Lomechusa is really a parasite, for he feeds upon the grubs of his hosts, though it is only fair to say that the Ants aid and abet him in this shameful practice, for they place him upon their own grubs as though inviting him to make a good meal. The Ants appear to think very highly of him, and not to mind sacrificing their grubs to him, although he is a voracious little beast and seriously affects the stability of the Ant society. He is the recipient of much attention and, in the event of danger threatening, it is their first care to get him to a place of safety. The effect of the presence of Lomechusa on the stability of the Ant community is thus referred to by Wasmann: "This brood-parasitism, in fact, causes the development of abortive individuals intermediate between the female and worker castes, and these intermediaries, which I have called pseudogynes, gradually bring about a degeneration of the parasitized colonies."

Wasmann says that the true character of all these Ant-nest Beetles may be tested by looking for the tufts of yellow or reddish-yellow hairs. If these are present on any part of the body they are a good certificate of the bona fides of the Beetle. It is a true messmate who gives as well as receives, and these hairs are the points at which the Ant receives the Beetle's benefaction. Look into the mouth-parts of a Beetle answering this test, and if it is found that the tongue is short and broad, and the palpi undeveloped, it is evident that the Beetle receives food from the mouth of the Ants. Some have in addition a special club-shaped formation of the antennæ, which are used to beat gently on the Ant—a supplication for food. There is also more or less of mimicry, both of form and action, in these true messmates. They supplicate the Ants for food with their antennæ, just as Ant does to Ant for the same reason. *Atemeles* even uses its fore-feet in this performance just as an Ant does—stroking the side of the head of the feeding Ant. Even the undesired interlopers of the genus *Myrmedonia* have learned the trick of stroking the Ant with their antennæ with the idea of placating them.

The true beetle-guests are always more or less red or yellow in colour.

It is impossible to give an account of all the beetles that are constantly found in the nests of Ants, and to give a mere list of their names would be uninteresting. Some of them are there merely as scavengers, but even these are useful to the community from a sanitary point of view, although they receive no attention from the Ants. It is scarcely to be wondered that, not being recognized by their hosts, they do not always have proper regard for the rights of the Ants, but are sometimes found stealing their food and their eggs. Among the interlopers who obtain a safe shelter and food (though not exactly parasitically) may be mentioned the larvæ of the beautiful Rose Chafers (*Cetonia aurata* and *C. floricola*) sometimes found in the nest of *Formica rufa* feeding upon the bits of twig and the pine-needles of which the nest is composed. *Myrmedonia funesta* and several other species of the same genus are commonly found in the nest of *Lasius fuliginosus*, the Black Ant, that constructs its galleries in decaying trees and rotting posts. Some of these, no doubt, are in the nest without the actual knowledge of the owners, and contrive to keep out of the way, for it has been found when certain of these Beetles are introduced into observation-nests, that the

Ants at once set upon the interlopers and kill them. In ordinary they apparently do not obtrude themselves upon the Ants, but when they are thrust into full view of their hosts the latter cannot ignore them. In some species this enmity appears to have brought about, through natural selection, a striking resemblance to Ants, for those that in any degree resembled Ants would escape notice, whilst those that were obviously not Ants would be killed off and leave no successors. *Myrmedonia funesta*, for example, is very Ant-like, and is said to give out an odour of formic acid like the Ants. It is not a friendly lodger, but feeds upon the eggs and larvæ of its hosts.

Dinarda dentata, another of the Beetles with short wing-covers (Staphylinidæ), was discovered by Grimm (1845) to be one of the Ant's true messmates. It is found in the nest of *Formica sanguinea*, and has a tuft of hairs on the hind body which the Ants lick. But Wasmann appears not so to regard it, for he speaks of it as a jackal, tearing in pieces "the bodies of the insects brought in as prey by the Ants, also the latter's dead, and their empty pupa cases. I once saw a *Dinarda dentata* steal an egg from a big mass of them in a nest of *Formica sanguinea* and creep with it into a corner.

I have often seen *Dinarda hagensi* take part of the food of two Ants feeding each other; it does so by raising itself between the two and licking the drops of food as they fall." But such an act of familiarity may not be displeasing to the Ant, and the disposal of dead bodies and waste substances is a distinct advantage to the hosts; and what Wasmann further says of it appears to justify Grimm's estimate. He says: "To the *menu* of *Dinarda dentata* we may add the soft larvæ and pupæ of the Acarina that live in the nest of its host. It prevents, as I have often noticed in my observation-nests of *Formica sanguinea*, the rapid increase of *Tyroglyphus wasmanni*, an increase which is so fatal to the Ants; it also destroys the young of Leolaps." Not only is it directly beneficial in these ways, but indirectly also by rendering service to their friend Lomechusa. "A *Lomechusa* in the big *F. sanguinea* nest which had stood for many years in my study, came out of a part of the nest used by the Ants as a waste bin for the refuse from their nest, and which swarmed with Mites." (Even the Mites are seen to be useful as scavengers.) "The upper part of the hind body of the Lomechusa was covered with these tiny creatures, which appeared like innumerable little white spots moving

rapidly about, and which, examined under the lens, turned out to be the larvæ and pupæ of *Leolaps myrmecophilus.* The *Lomechusa* seemed very uneasy; it ran nervously up and down, its agitation contrasting strangely with its usually solemn demeanour. It then met a *Dinarda dentata*, which reared up on to its back with its fore-feet. It now stood quite still, and in a few seconds the greater part of the mites were devoured or chased away by the Dinarda."

A group of these ant-nest beetles is known as the Paussidæ, which are remarkable for the extravagant forms of their antennæ, which are broad and elliptical, shaped like ribbons, antlers, scimitars, drumsticks and boats. *Paussus sphœrocerus* has spherical antennal clubs which are suspected to be lamps. The Paussidæ also possess offensive glands like those of our Bombardier beetle (*Brachinus crepitans*), and in one species these are said to secrete pure iodine.

Escherich says of one species: "*Paussus turcicus*, which I met with in Asia Minor, is extravagantly loved by its hosts (*Pheidole pallidula*), is continually licked, caressed with the antennæ and not infrequently carried about in the nest. Much less affection is lavished by its hosts on the decidedly

smaller *Paussus favieri*, which I studied in North Africa (Oran). In this case it is hardly possible to speak of a friendly relationship, for the ants usually ignore their guest completely, and only occasionally lick it in a perfunctory manner. Cooler still, or rather inimical, is the behaviour of ants to *Paussus arabicus*, which I had an opportunity to study in northern Abyssinia (Erythrea)." Small wonder if the ants do treat these guests with coolness, for they feed upon the ant brood.

Even those Beetles which are accepted as true friends and messmates are not without their disadvantages to the community, and eventually bring about its ruin, by their consumption of too great a proportion of eggs and grubs, which results in an insufficiency of workers to carry on the nest.

Among those undesired inmates of Ants' nests are several species of moths of the smaller kinds. One of these is the pretty little *Myrmecozella ochracella*, which is only three-quarters of an inch in wing expanse. Its fore-wings are yellow and its hind-wings grey with a yellow fringe—what an average person would pass as "one of those troublesome clothes-moths." The caterpillar feeds upon the nest-material of *Formica rufa* and *Formica pratensis*, and indicates at once that it is not present

by the consent of the nest owners, for it weaves the nest-material into galleries, in which it feeds unseen. It has been found in nests at Rannoch and in the New Forest. Stainton says the moth is only to be found in the nests and that the ants take no notice of it whilst it is alive, but if one be killed and thrown to them it is immediately carried off by them. Very similar in colour and habit is *Tinea biselliella*, which is one of our destructive house-moths—the one whose caterpillar gets inside the coverings of beds, sofas and cushions that are stuffed with feathers, hair, or wool, and eats away the stuffing. Mr. Donisthorpe found it in his observation-nest of *Formica rufa*, but is not certain whether it was introduced with the "wild" material from Weybridge or migrated from his household furniture. If an inhabitant of outdoor nests it does not destroy anything the Ants value, for it is known to restrict its depredations to materials of animal origin.

Another of these tiny moths, *Brachmia gerronella*, was found by Mr. Donisthorpe in a nest of *Lasius fuliginosus*. When he opened the nest the moth flew up, but settled again among the Ants. He says: "It did not fly away when the Ants, which were very excited, ran against it, and I did not see

it attacked." Probably they were urging it to save itself, but the moth was resolved to live or die with its friends. Unfortunately, nothing is known of the habits or life-history of this moth.

A beetle that has long been known as a messmate of the Ant is *Atemeles emarginatus*. It is one of the same family as *Lomechusa*—the Staphylinidæ—and is only about a fifth of an inch long. It is brown in colour, with a black head and reddish wing-covers. Its colouring harmonizes fairly with several species of Ants, and it has been found in the nests of *Formica fusca*, *Myrmica lævinodis*, *M. ruginodis* and *M. scabrinodis*. It is a species that is cherished by the Ants, and in the case of a disturbance of the nest, they seize the chrysalides of this Beetle in the same way as they do their own and run off with them to the deeper and safer galleries.

A fly, *Microdon mutabilis*, spends its larval existence in the nests of various species of Ants. It is a peculiar disc-shaped grub—its flatness probably having reference to its desire not to get in the way of the Ants or to attract their attention. They pass it constantly in their galleries but take no notice of it. If they know of its presence they must tolerate it; but they show no interest in it. It is not a messmate, neither is it a parasite, for it

PLATE 46 ANTS' NEST FLY. Page 196

Microdon passes its earlier stages in the nests of Ants. The first photo shows the larva, the second the mature insect.

Photos by H. K. Donisthorpe, F.Z.S.

neither attacks them nor their food. It is in truth a scavenger, living upon their excreta, as do some other of the tolerated lodgers.

Several species of Spiders habitually reside in Ants' nests; but we think there can be no question of commensalism here. The Spiders being all carnivorous, it is more than probable that the helpless young of the Ants contribute largely to their sustenance. Several of these Spiders, though known on the Continent, had never been observed to inhabit this country until Mr. Donisthorpe turned them up in Ants' nests. Their fidelity to Ants' nests as their habitat is, of course, sufficient to account for their being unknown—as in the case of *Lomechusa*. Certain of these Spiders closely mimic Ants; but this is a trait of many Spiders in all parts of the world, as Pocock has well shown. Donisthorpe says of one of these Spiders (*Micaria pulicaria*) he took from the nest of *Lasius niger* at Mickleham that it is very like the Ants with which it occurred. "The Spiders were rapidly running about in the nest and the 'runs' of the Ants, and were very difficult to distinguish from them." Of the related species, *Micaria scintillans*, which mimics a large black Ant (*Formica rufibarbis*), Cambridge says: "The grassy slopes where this

Spider occurs (at Portland) are also numerously frequented by a large blackish Ant, to which the Spider bears so close a resemblance that, even after much practice, it requires a close examination to distinguish (before capture) between the Ant and the Spider, both have also a similar habit of running hurriedly now and then up a grass stem, as if to get a larger range of view—or it may be that both are in search of the same prey; both again, on the first inkling of danger, betake themselves to the stems and roots of other low herbage." In the cases of mimicry between exotic forms of Spiders and Ants, they are mostly between species that have the same haunts, and apparently friendly feelings towards each other. The Spider assumes the ant-likeness obviously for the sake of the protection afforded by the imposition from wasps, who are great enemies to Spiders but respect the formic acid of the Ants. The likeness to their own race assumed by the Spiders may have led the Ants to respect and tolerate them as lodgers in their nests. Familiarity does not always breed contempt, but often results in lasting friendship. Though some of these Spiders may lie under a suspicion of parasitism, others are certainly no worse than mutualists, taking advantage of their

PLATE 47 ANT NEST MITE. Page 198

The upper photo shows the Mite Antennophorus. In the lower the Mites are seen sitting on the Ant's head.

Photos by H. K. Donisthorpe, F.Z.S.

likeness to Ants, but conferring no benefit upon the Ants by their presence.

Allied to the Spiders are the Mites (*Acarina*), and, owing to their almost universal presence, it is in no way surprising that these also are inhabitants of the hotels known as Ants' nests. But a number of species are permanent dwellers there, and from their familiar behaviour may be considered to regard the nest as their own. To adopt a different figure of speech, small and helpless as they are, they do not hesitate to beard the lion in his den, for some of them perch upon the Ant's head and even cling to his chin, although this position clearly annoys the Ant. This, for example, is the behaviour of *Antennophorus uhlmanni* as described by Father Wasmann: "It is generally on the Ant [*Lasius mixtus*, *L. niger*, or *L. flavus*], in most cases on the underside of the head. It makes use of this favourable position, to tickle the sides of the Ant's head with its front feet, which are like antennæ—hence its name 'antennæ-bearer'—till the Ant lets fall a drop of food, which the parasite licks up. The Ants tolerate the impudent rascal simply because they are unable to get rid of it. I have often seen them make desperate attempts to knock it off." That remark, which probably applies to all

these Mites, puts them out of court in a book on Messmates. At the best they are scavengers, feeding on the animal and vegetable refuse that abounds in all Ants' nests.

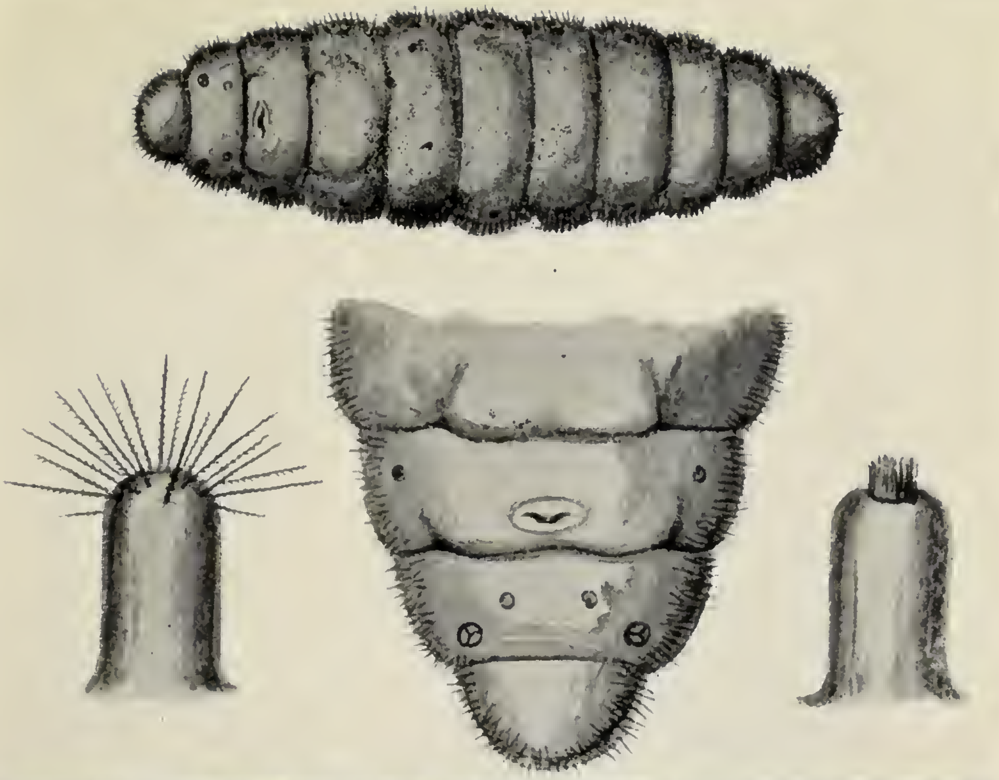
We fear that much the same thing must be said of the terrestrial Crustaceans of the Isopod family that have been lodgers in Ants' nests for untold ages. They appear to be very catholic in their tastes, for they have been found by Donisthorpe and Wasmann in the nests of pretty well all the Ants they have investigated. So long as it is an Ants' nest they are not particular what species of Ant inhabits it. Chief of these Crustaceans is *Platyarthrus hoffmannseggii*, one of the Woodlouse group, which has been so long addicted to a life in the darkness of the nest that its eyes from disuse have vanished altogether, and its body is entirely white, because the light of day has not been allowed to develop any pigment in its tissues. Although it is distributed over nearly the whole of Europe, it has never been found outside an Ants' nest. It is a slow-moving creature, of which the Ants take not the slightest notice, familiarity in this case clearly breeding contempt.

There are four other of the Woodlouse tribe that are found habitually in Ants' nests, and their

names are *Lucasius myrmecophilus*, *L. pallidus*, *L. tardus* and *L. pauper*, and their Latin names are eloquent of the impression their underground life and its effects produced upon their scientific sponsors.

We have finished with the nest-haunting insects, though we have by no means exhausted them ; but we must return to the class, for there are some interesting facts to relate in reference to the friendships existing between the Ants and the caterpillars of several of the "Blue" butterflies. We have said several, because we do not wish to make too sweeping a statement. We might have said with every probability of truth "most," for the "several" refers to our native species, and we are only just beginning to learn something about the matter. But from all parts of the world details are coming in, showing that the exotic Blues, so far as their larval history has been worked out, have similar friendly relations with the Ants of their own countries. These relations are based on the fact that a "Blue" caterpillar bears on the eleventh ring or segment of his body (counting backwards) a mouth-like gland in the middle line of the upper side. Through the slit of this "mouth" a little prominence can be protruded, and this emits a

colourless drop of fluid which is believed to be sweet. On the next (twelfth) segment there is a pair of short prominences surmounted by a circlet of spiny or feathery hairs, which appear to be erected at intervals as a signal to the ants that are always in its neighbourhood. They are usually retracted within the body, but when the caterpillar wishes to attract the attention of an ant, he is believed to expand these, and they are taken by the ant to indicate that it will be worth his while to approach the caterpillar and inquire after its health. The ant, seeing the caterpillar's signals, runs to it, climbing over its back and drumming upon the hinder parts with its antennæ, much as it does to the Aphis. The larva shows no sign of alarm, indeed goes on feeding as though still alone, and does not even wince under the tickling contact of the Ant's feet and antennæ. But the fondling has had its effect upon the apparently imperturbable caterpillar all the same, and it has begun to emit the sweet fluid from the gland on its back. The Ant may then be seen licking the last two or three segments of the caterpillar, especially the eleventh. The caterpillar, apparently unconcerned, goes on emitting the sweet secretion at intervals of about twelve seconds, and if there is any flagging in the



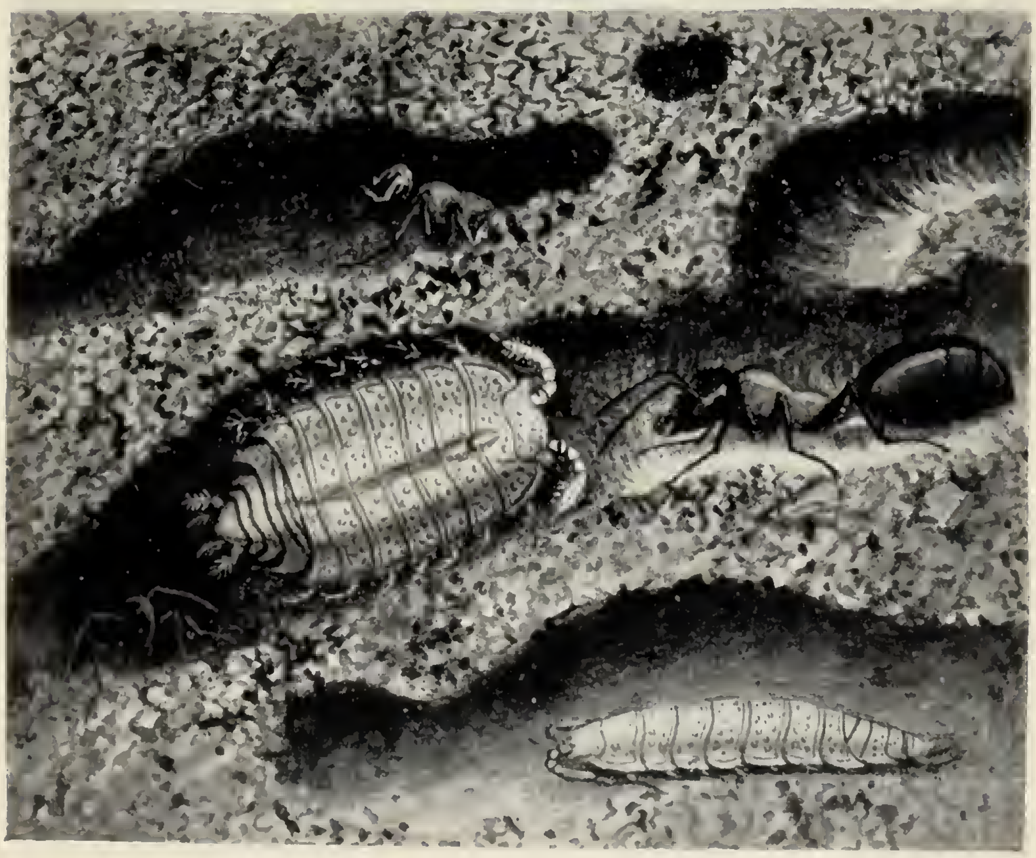


PLATE 48 CATERPILLAR OF "BLUE" BUTTERFLY. Page 202

With enlarged figure of hinder segments showing honey-glands; also of extensile organ with hairs extended and withdrawn.

ANT NEST WOODLOUSE.

By T. Carreras

output before the Ant is satisfied the latter begins again the caressing process.

The fact that Ants paid considerable attention to the caterpillars of the Blues was known at the end of the eighteenth century, but the reason for it was not understood, until Guenée about the middle of last century described the signalling apparatus and the secreting organs in the Long-tailed Blue (*Lampides bœticus*) ; and Zeller about the same time refers to the cones on the back of the caterpillar of the Chalkhill Blue (*Agriades coridon*) which the Ants are so fond of licking ; but in 1877 a Canadian entomologist, Mr. W. H. Edwards, gave fuller particulars from his observation of the behaviour of Ants towards the caterpillars of *Celastrina pseudargiolus*, which is regarded as the American form of our Holly Blue (*Celastrina argiolus*). Mr. Cook in his work on the Mound-making Ants of the Alleghanies also refers to the same species. One of our rarest species, the Large Blue (*Lycæna arion*), when it has changed its skin for the last time, appears to take no vegetable food—at least that is the experience of entomologists in breeding it—and it is suspected that in a state of nature it retires underground and is fed by the Ants who have benefited so long by its sweet

secretions. Normally, this caterpillar feeds upon Wild Thyme, which is a very frequent accompaniment to Ants' nests, so that in the district it inhabits the Ants find it close at hand. Dr. Brauns has actually found these caterpillars, of several species, in Ants' nests at the Cape.

There is no doubt that in all these cases the Ants by their constant attendance on the "Blue" caterpillars often keep off the devastating ichneumon-wasps that seek to lay their eggs in the helpless caterpillar, so that its payments to the Ants in the shape of nectar are well expended. At the present time more than sixty species of "Blue" caterpillars, representing twenty-nine genera of Lycænidæ are known to be attended by ants.

The Foraging Ants (*Eciton*) of South America are described as the terror of all small animals; but notwithstanding they have a number of guests or associates who must either know the soft side of the Eciton or contrive to delude him. This task, perhaps, is rendered easy by the fact that the sight of the Ecitons is poor and restricted. The Ecitons are remarkable for not possessing the compound eyes that are so prominent a feature of most insects. They have only the simple ocelli which are of various degrees of development in

different species of the genus, in some being small and flat, and therefore not very useful; in others they are twice the size, of considerable convexity, and therefore of greater value. Other species have ocelli intermediate between these extremes. Bates says that this poverty of sight is an advantage to them with their marching habits, as it enables them to keep together by the aid of other senses. *Eciton erratica* is altogether blind, but species which hunt singly and not in regiments have well developed eyes.

The majority of the beetle companions of these Foraging Ants are Staphylinidæ as in the Formicas, etc., and they actually accompany their hosts on the march, often riding on the egg-clusters which the Ants take with them. Here mimicry plays an important part, for the guests are got up in such a way that their hosts are deceived into accepting them as of their own kind. But with poor-sighted Ants like *Eciton prædator* and *Eciton cæcum*, it would be useless to try to impose upon them by mere colour mimicry; and consequently Wasmann tells us that "their mimicking guests, *Ecitonella*, *Ecitonides*, and *Mimeciton*, possess no similarity of colouring," but mimic only to the touch! They are built exactly like Ants: the abdomen is

plump and arched, the useless "wing-covers" that cover no wings are made to resemble the first joint of the Ant's hind body, the antennæ are whip-shaped and have a long first joint identical with that of the Ant, long spider-like legs as in the Eciton, and hair growths practically identical; the whole being calculated to deceive the sense of touch. In the case of *Eciton californicum*, which has large, fairly developed eyes, apparently able to distinguish between shades of colour, the mimicking beetle is of the exact rust-red colour of its host.

Another of these Beetles (*Xenocephalus*), though not a friend, attaches itself to the Ecitons, and is protected from their resentment by the development of a sort of carapace not unlike that of the King Crab (*Limulus*), under which its legs, head and antennæ are hidden, and there is consequently no part which a hostile Ant can attack with its powerful jaws.

X

MESSMATES OF TERMITES

X

MESSMATES OF TERMITES

Although the Termites are familiarly known to the general public as White Ants, it is not desirable so to call them, as they are in no wise related to the Ants, and nothing is more potent than a false name in the perpetuation of error. Seeing how widely distributed they are in hot countries and what enormous nests they construct, it would perhaps be a matter for surprise if such admirable cover had not been discovered by some of the creatures that have commensal tendencies. Wasmann, in truth, has found that there are more than one hundred insects that habitually take up their residence in the nests of Termites, some being true Messmates, others merely lodgers. Here, again, the slender, more or less Ant-like beetles with short wing-covers (Staphylinidæ) form the majority; and it is remarkable evidence of their adaptability to the circumstances of their

environment that many of these Termite guests have developed swollen abdomens, which gives them a superficial resemblance to their hosts. There are other differences between these and their allies who are guests of the real Ants. In the Termite guests there are no tufts of yellow hair to be licked; there is no approximation to the form of antennæ found in their hosts. Instead of stroking with their antennæ to supplicate their hosts for food, the Termite beetles use their palpi—the tactile filaments attached to the lips—which are much swollen and provided with specially developed muscles to make them available for this purpose.

The Termite's nest is a much more durable and conspicuous structure than an Ant's nest. The nest of our Wood-Ant (*Formica rufa*) may be an imposing erection at the foot of a pine tree, though the uninitiated is very apt to regard it as a mere heap of pine-needles that some tidy forester has swept up; but it can be all scattered by one's foot in a minute. The Termite builds of more durable material. By a judicious combination of triturated earth and his own secretions he elaborates a material that has the qualities of Portland cement; it sets as hard as stone, and looks like red brick.

Some of these " hills " or termitaria exceed twenty feet in height, and are the work of not only many generations of Termites, but of several species, each species occupying a particular level, and often of differently compacted material from that used by its neighbours on the " flats " above and below. The Australian colonists have an erroneous idea that no one has ever seen a newly erected hill, and that there is mystery about their erection; but this, of course, is solely due to their lack of observation. These weather-proof and roomy pyramids and cupolas have been exploited by all sorts and conditions of animals, who have found the subterraneous entrances to them or have dug into them from the exterior. Rats, of course, of various species have found them eminently suitable for their love of a secluded retreat, and they almost certainly feed freely on the helpless pupæ. Large snakes follow, probably, along the routes enlarged by the rats, and in all likelihood serve the rats as these have done the Termite pupæ. Lizards, centipedes and beetles, are other intruders that may be found in hundreds in these nests, and it may safely be said, from what we know of their usual habits, that they all take toll of the helpless but succulent Termites. But for little checks of this kind upon

their normal rate of increase there would be no room for other animals in those parts of the world favoured by the Termites.

But it is of friendly and apparently welcome guests that we wished to speak in this chapter, whereas we have been led very near to embarking upon the tempting subject of Termite economy. The Staphylinidæ that have adopted the termitarium as their dwelling-place represent many genera, and the mode of life has so modified their structure that it has caused some of these genera to be specially erected to receive them, and the authorities have given these names which often indicate the habit of the species included. Thus, we find such generic names as *Termitogaster*, *Termitobia*, *Termitochara*, *Termitomorpha*, *Termitophysa*, and *Termitodius.* The structure of the mouth parts of many of these beetles leaves no doubt that they are fed by the Termites, and it may be that the food given to them may be the cause of the swollen abdomen. These beetles, however, are not all "Staphs," and a Ground-beetle named *Orthogonius shaumi* is among them. Its larvæ have been found in various stages of growth, and whilst these are known to be thin and slender at first, they later acquire a long bottle-shaped form under the care and judicious

feeding of their hosts, and so present a general resemblance to the worker Termites.

Strange to say, two genera of Scarabs or Dung-beetles are also included among the Termites' commensal lodgers.

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Printed by Hazell, Watson & Viney, Ld., London and Aylesbury.